MINAMATA ONLINE

SEASON 2 - 2021 2022

REACTIVE MERCURY IN AIR

MINAMATA CONVENTION ON MERCURY

This online webinar will look into how atmospheric mercury monitoring can support the Minamata Convention – policy making, implementation and evaluation. This event will focus on comparability of measurements of the three forms of atmospheric mercury: gaseous elemental (GEM), gaseous oxidized (GOM), and particulate bound (PBM). Currently, comparability of GEM can be demonstrated, while limited metrological infrastructure for traceable, validated, and accurate measurements of oxidized mercury species in the atmosphere exists.

REGISTER NOW: 1 MARCH 2022

16H00-17H30 CET

Please register for the WebEx session using the link above.

Information about Minamata Online   Check the Season 2 calendar

MERCURY SCIENCE

SPEAKERS

Mae Sexauer Gustin
University of Nevada, Reno

Seth Lyman
Utah State University

Reno Lynwill Martin
International Conference on Mercury as a Global Pollutant

Eisaku Toda
Senior Policy and Coordination Officer

Milena Horvat
Jožef Stefan Institute, Slovenia

Sarrah Dunham-Cheatham
University of Nevada, Reno

Iris de Krom
National Metrology Institute, The Netherlands

Housekeeping notes

MINAMATA CONVENTION ON MERCURY

- You may wish to test (and adjust) your **speaker and microphone settings** by opening the **Audio & Video** menu at the top-left corner of your screen.

- You can open the **Participants** panel and the **Chat** panel by clicking the respective icon at the bottom-right corner of your screen.

- You may wish to type question(s) in the chat box and send to “everyone”.

- If you need any **technical assistance**, please put your message in the chat box and send it to the ‘host’.

- Kindly note that this session is **recorded and broadcasted.** Recording of this session and the presentation slides will be made available through the Minamata Convention website after the session.

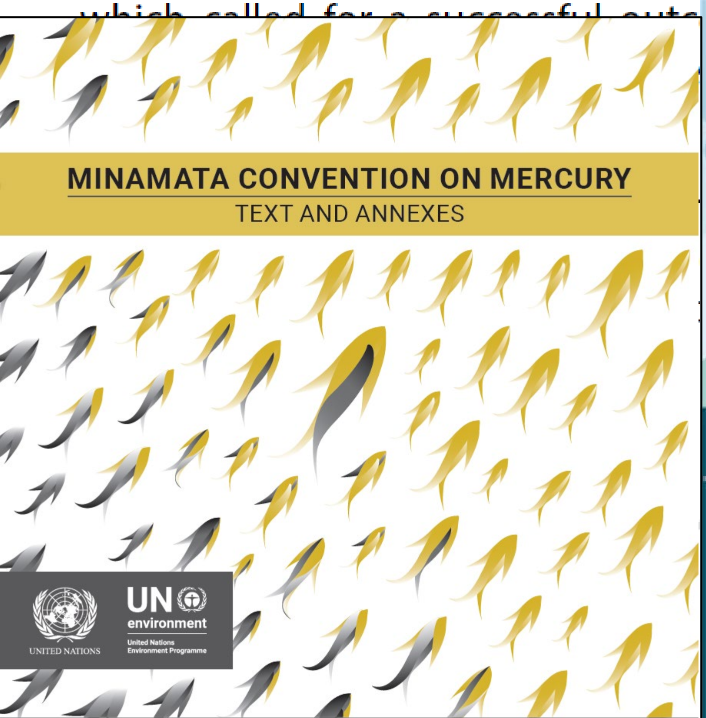
MINAMATA CONVENTION ON MERCURY

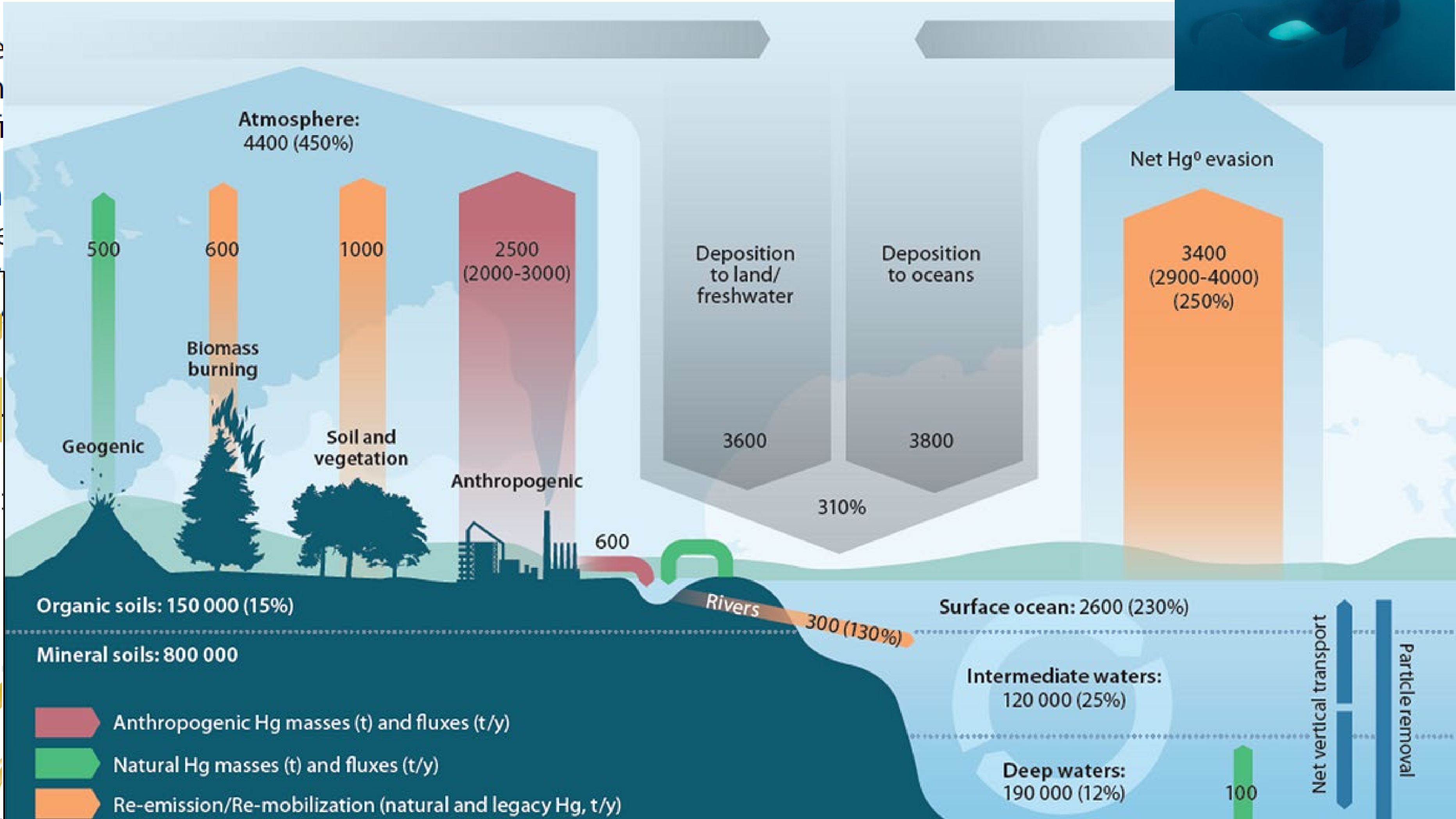
The Parties to this Convention,

Recognizing that mercury is a chemical of global concern owing to its long-range atmospheric transport, its persistence in the environment once anthropogenically introduced, its ability to bioaccumulate in ecosystems and its significant negative effects on human health and the environment,

Recalling decision 25/5 of 20 Fe
of the United Nations Environmen
action to manage mercury in an effi

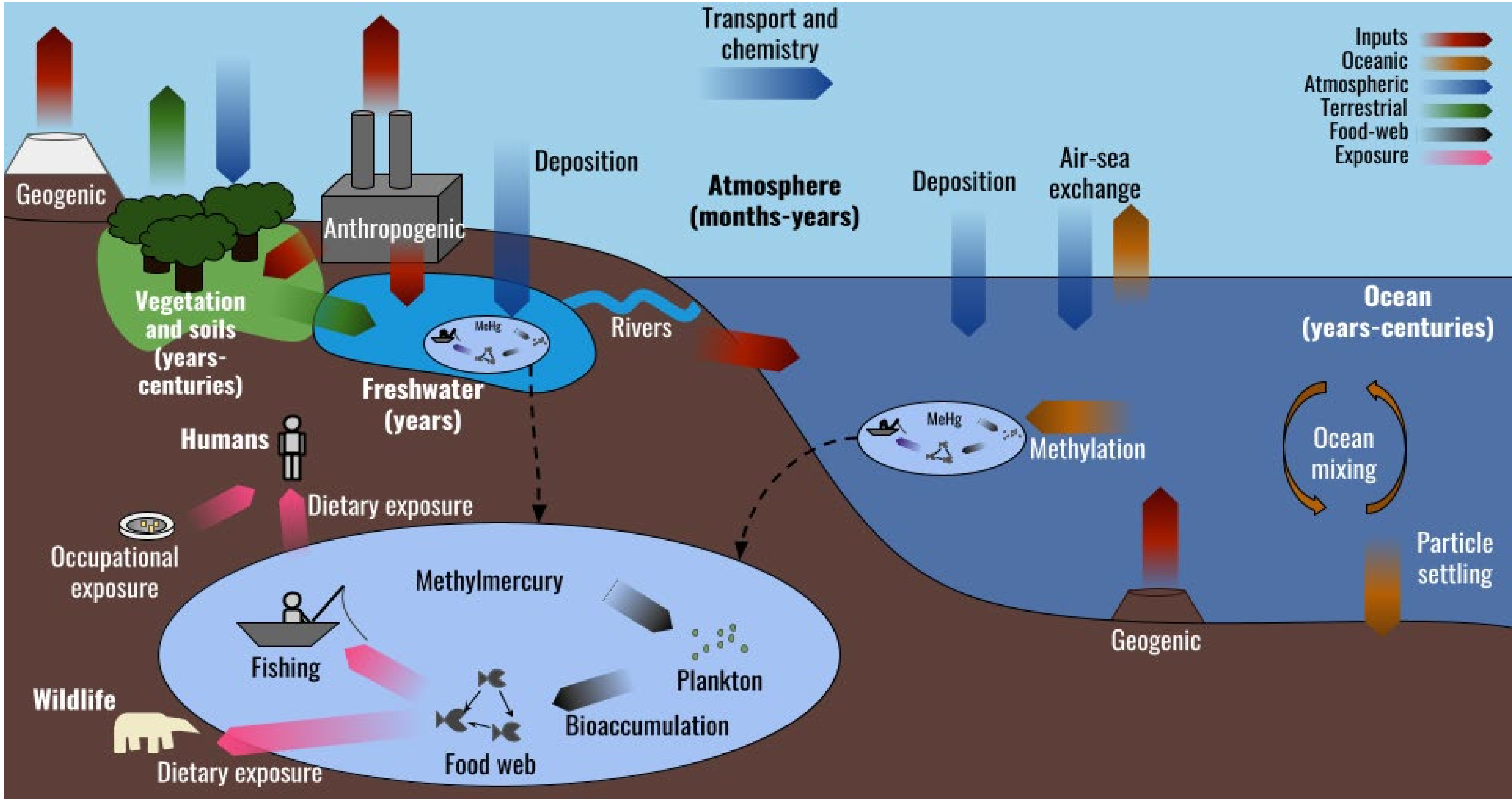
Recalling paragraph 221 of th
Nations Conference on Sustainable
which called for a successful outc





Article 1
Objective

The objective of this Convention is to protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.



Article 19
Research, development and monitoring

1. Parties shall endeavour to cooperate to develop and improve, taking into account their respective circumstances and capabilities:

(a) Inventories of use, consumption, and anthropogenic emissions to air and releases to water and land of mercury and mercury compounds;

(b) Modelling and geographically representative monitoring of levels of mercury and mercury compounds in vulnerable populations and in environmental media, including biotic media such as fish, marine mammals, sea turtles and birds, as well as collaboration in the collection and exchange of relevant and appropriate samples;

(c) Assessments of the impact of mercury and mercury compounds on human health and the environment, in addition to social, economic and cultural impacts, particularly in respect of vulnerable populations;

(d) Harmonized methodologies for the activities undertaken under subparagraphs (a), (b) and (c);

(e) Information on the environmental cycle, transport (including long-range transport and deposition), transformation and fate of mercury and mercury compounds in a range of ecosystems, taking appropriate account of the distinction between anthropogenic and natural emissions and releases of mercury and of remobilization of mercury from historic deposition;

Article 22
Effectiveness evaluation

1. The Conference of the Parties shall evaluate the effectiveness of this Convention, beginning no later than six years after the date of entry into force of the Convention and periodically thereafter at intervals to be decided by it.

2. To facilitate the evaluation, the Conference of the Parties shall, at its first meeting, initiate the establishment of arrangements for providing itself with comparable monitoring data on the presence and movement of mercury and mercury compounds in the environment as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations.

3. The evaluation shall be conducted on the basis of available scientific, environmental, technical, financial and economic information, including:

(a) Reports and other monitoring information provided to the Conference of the Parties pursuant to paragraph 2;

(b) Reports submitted pursuant to Article 21;

(c) Information and recommendations provided pursuant to Article 15; and

(d) Reports and other relevant information on the operation of the financial assistance, technology transfer and capacity-building arrangements put in place under this Convention.

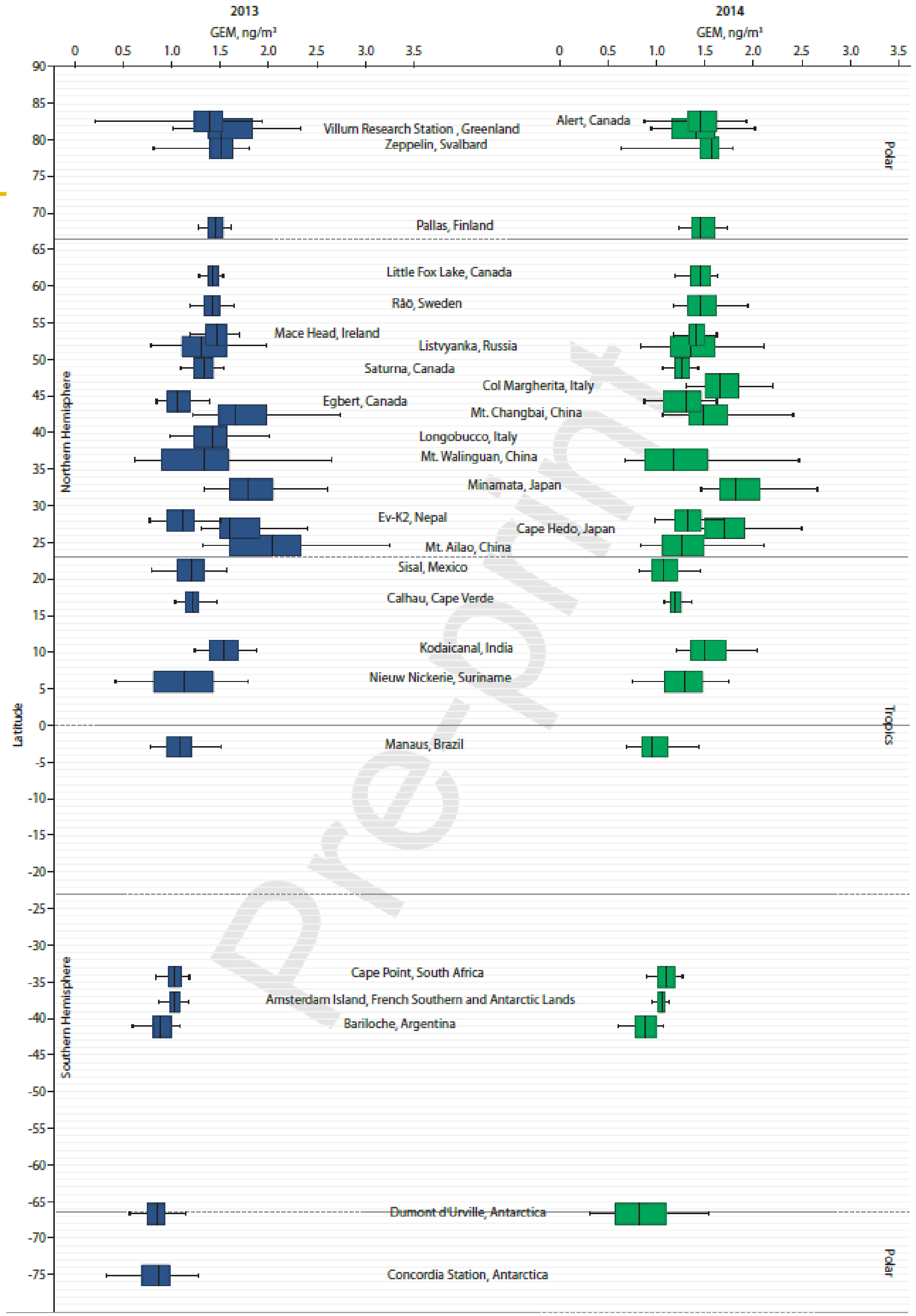


Figure 4.2 Hemispheric gradient in GEM concentration for GMOS data in 2013 and 2014. Sites are organized by latitude. For each box the midline indicates the median, the box indicates the 25th and 75th percentiles, and the whiskers indicate the 5th and 95th percentiles (Sprovieri et al., 2016).

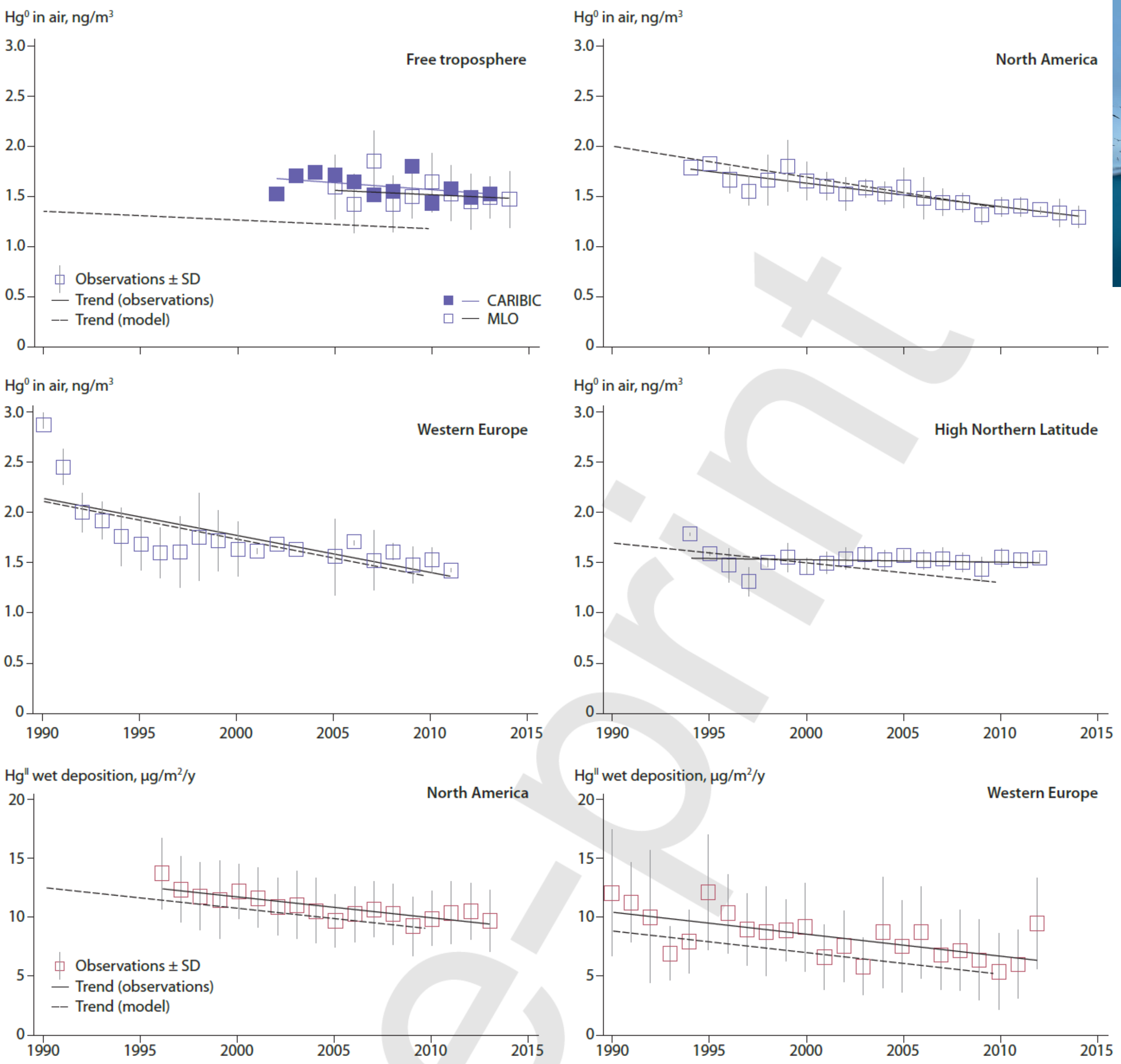
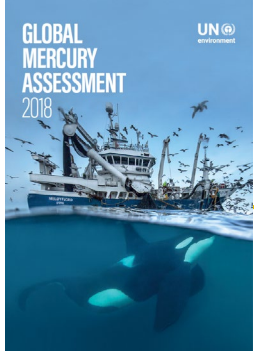


Figure 8.2 Observed and modelled trends for 1990 to 2013 in atmospheric gaseous elemental Hg concentrations (upper four plots) and divalent Hg^{II} wet deposition fluxes (lower two plots) in different regions of the Northern Hemisphere. Observations for individual years are shown as squares with linear regression as a solid line. The dashed line is the trend from the GEOS-CHEM simulation using the revised anthropogenic emissions inventory for 1990 and 2010. The data are averaged regionally across the free troposphere, North America, Western Europe, and high northern latitude regions. From Zhang et al. (2016c).



Reactive Mercury in Air

This online webinar will look into how atmospheric mercury monitoring can support the Minamata Convention – policy making, implementation and evaluation. This event will focus on comparability of measurements of the three forms of atmospheric mercury: gaseous elemental (GEM), gaseous oxidized (GOM), and particulate bound (PBM). Currently, comparability of GEM can be demonstrated, while limited metrological infrastructure for traceable, validated, and accurate measurements of oxidized mercury species in the atmosphere exists.

Programme

- **Lynwill Martin: Guidelines for mercury monitoring for effectiveness evaluation – air**
- **Iris de Krom: Comparability of the measurement results for gaseous elemental mercury**
- **Mae Sexauer Gustin, Milena Horvat, Seth Lyman, Sarrah Dunham Cheatham: Practical demonstration of oxidized mercury measurements: sampling artefacts and calibration**
- **Discussion: moderated by Milena Horvat**
- **Closing – Minamata Convention Secretariat and ICMGP**

JUL 2021

THU 22 JUL — 15h30-17h00
Global change and biogeochemical mercury cycling

AUG 2021

MON 16 AUG — 13h00-14h00
Introduction to the new website

MON 23 AUG — 11h00-12h30
Mercury in the Southern Hemisphere

SEP 2021

WED 1 SEP — 13h00-14h30
Information session on the proposals to amend Annexes A and B of the Convention

TUE 7 SEP — 13h00-14h00
Getting prepared for full National Reports

TUE 14 + THU 16 SEP — 13h00-14h00
Reporting guidance and online reporting tool: Part I + II

MON 20 / TUES 21 SEP — 16h00-17h00, 10h00-11h00
Briefings on documents tabled at COP-4.1

TUE 21 SEP — 14h30-16h00
Mining without mercury: How technology can support the transition to mercury-free ASGM sector

MON 27 SEP — 08h00-12h30
Regional Preparatory Meeting: Asia-Pacific (CLOSED)

OCT 2021

MON 4 OCT — 11h00-15h30
Regional Preparatory Meeting: Africa (CLOSED)

FRI 8 OCT — 14h00-21h00
Regional Preparatory Meeting: Latin America and the Caribbean (CLOSED)

MON 11 OCT — 10h00-14h30
Regional Preparatory Meeting: Eastern European States (CLOSED)

MON 18 OCT — 12h00-14h00
Budget session ahead of COP-4.1 (CLOSED)

TUE 19 OCT — 14h00-15h30
Health risks of mercury in the context of global socio-environmental variability

NOV 2021

1-5 NOV
COP-4.1 ONLINE SEGMENT

WED 17 NOV — 12h00-13h30
Mercury emission from coal

MON 22 NOV — 09h00-10h00, 15h00-16h00
40 Days to go on National Reports: Check-in on any questions

MON 29 NOV — 15h00-16h00
Top-up information session on National Reports in Spanish

MON 30 NOV — 14h00-15h00
Top-up information session on National Reports in French

DEC 2021

WED 15 DEC — 13h00-14h00
Consultations on the framework for evaluating the efectiveness of the Convention

JAN 2022

TUE 25 JAN — 13h00-14h30
Consultation session on the framework for evaluating the effectiveness of the Convention: Part I

THU 27 JAN — 13h00-14h30
Consultation session on the framework for evaluating the effectiveness of the Convention: Part II

FEB 2022

1-3 FEB — 13h00-14h30
Briefings on documents at COP-4.2

MON 7 FEB — 08h00-12h30
Regional Preparatory Meeting: Asia-Pacific (CLOSED)

TUE 8 FEB — 11h00-15h30
Regional Preparatory Meeting: Africa (CLOSED)

WED 9 / FRI 11 FEB — 14h00-21h00
Regional Preparatory Meeting: Latin America and the Caribbean (CLOSED)

THU 10 FEB — 10h00-14h30
Regional Preparatory Meeting: Eastern European States (CLOSED)

WED 23 FEB — 13h00-14h00
Information session on national reporting: implementation review and compliance

THU 24 FEB — 13h00-14h00
Information session on the Financial Mechanism

MAR 2022

7-11 MAR — TIME: TBC
Pre-COP4 online side events

TUE 8 MAR — 14h00-15h00
Promoting gender equality in the implementation of the Convention

9 MAR — 13h00-14h00
Information session on the proposed programme of work and budget for 2023

19-20 MAR — TIME: TBC
In-person Regional Preparatory Meetings (CLOSED)

21-25 MARCH
COP-4.2 IN-PERSON SEGMENT

STREAMS

- Implementation review and support
- Mercury science
- COP-4 preparations

In the run-up to the fourth meeting of the Conference of the Parties to the Minamata Convention on Mercury (COP-4), that will convene in two segments — **COP-4.1** online and **COP-4.2** in-person —, the second season of Minamata Online provides an opportunity to better understand the policy and scientific aspects of the Convention.

Season 2 also responds to the valuable feedback from the over 1,700 participants that took part in last year's presentations, Q&A sessions and panel discussions.
Join us again: registration available at the Minamata Convention website.
http://www.mercuryconvention.org

All schedules are indicated in Geneva time
Last update: 31 January 2021

MINAMATA CONVENTION ON MERCURY

www.ilmexhibitions.com/mercury2022/

ICMGP

MERCURY AS A GLOBAL POLLUTANT
24TH - 29TH JULY 2022
VIRTUAL EVENT

REDUCING MERCURY EMISSIONS TO ACHIEVE A GREENER WORLD

EXECUTIVE COMMITTEE

Dr Lynwill Martin
Chairperson:
Conference

Dr Joy Leaner
Co-Chairperson:
Conference

Prof Vernon Somerset
Co-Chairperson:
Scientific Committee

Dr Chavon Walters
Co-Chairperson:
Local Organising
Committee

Ms Maria Cuoto

Prof Ralf Ebinghaus

Prof Robert Mason

Mr Marcus Pattison

Mr Rico Euripides

Joined July 2021

Dr Alexandra (Sandy) Steffen

Prof Dr Jozef Pacyna

Assoc Prof Asif Qureshi

ICMGP | MERCURY AS A GLOBAL POLLUTANT
24TH - 29TH JULY 2022
VIRTUAL EVENT

REDUCING MERCURY EMISSIONS TO ACHIEVE A GREENER WORLD

LATEST NEWS | CALLS:

Announcing the ICMGP 2022 - Katherine Mahaffey Lifetime Achievement Award Winner

On the behalf of the mercury scientific community, the Executive Committee and Scientific Steering Committee of the 15th International Conference on Mercury as a Global Pollutant, cordially congratulate Professor Robert Mason for receiving the Katherine Mahaffey LAA Award. ... **Read More**

Call for papers on Mercury Research

The Scientific Committee of ICMGP The 15th International Conference on Mercury as a Global Pollutant have announced a Call for Papers. The 2022 ICMGP conference will be held virtually from the 24th-29th July. Being held virtually will now give more access and opportunities for Mercury Researchers ... **Read More**

Extended until 15 March

https://www.ilmexhibitions.com/mercury2022/

LATEST NEWS | CALLS:

Week of 18 – 22 July

ICMGP Workshops (13) ASGM, Coding, Arctic ect.

Topic on Reactive Mercury Measurement will be presented also by Mae Gustin & Team

Week of 24 – 29 July Plenary Talks

Mon: Global Change and Biogeochemical Mercury Cycling

Health day Tue: Minamata Storyteller (Setting the Scene)

Correct use of Hg Guideline Values by Non-health Experts

Wed: Next Gen – Future of Mercury Research at a Glance

Thu: Industrial Emissions and Challenges

LATEST NEWS | CALLS:

24 March

5th Scientific Steering Committee Meeting (Abstracts)

Registration to open middle April

Guidelines for mercury monitoring for effectiveness evaluation

Reasoning Behind the Document

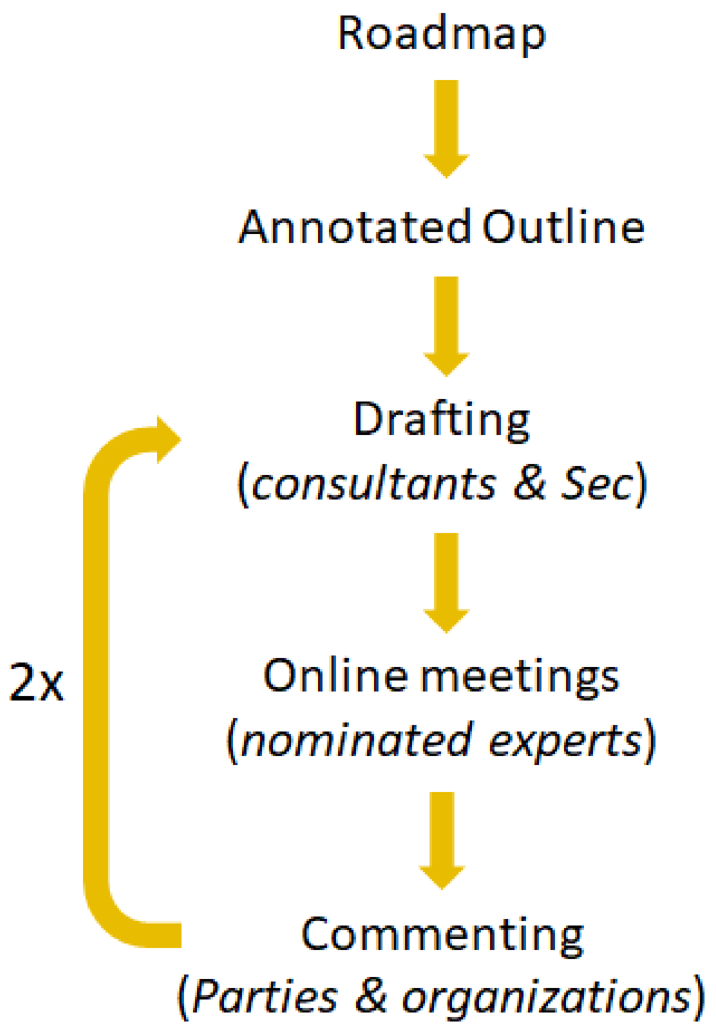
Lynwill G Martin

Aim & Process of Monitoring Guidance

(i) explain the role of **monitoring** in the **effectiveness evaluation** and set realistic expectations about what can be learned over time;

(ii) provide guidance **to parties and organizations** that are **currently conducting monitoring programmes** on what data and accompanying information would inform the effectiveness evaluation; and

(iii) provide guidance to parties and organizations who wish **to develop new monitoring programmes** or improve existing ones, with a view to contributing to the effectiveness evaluation.



Source: UNEP/MC/COP.4/INF/12

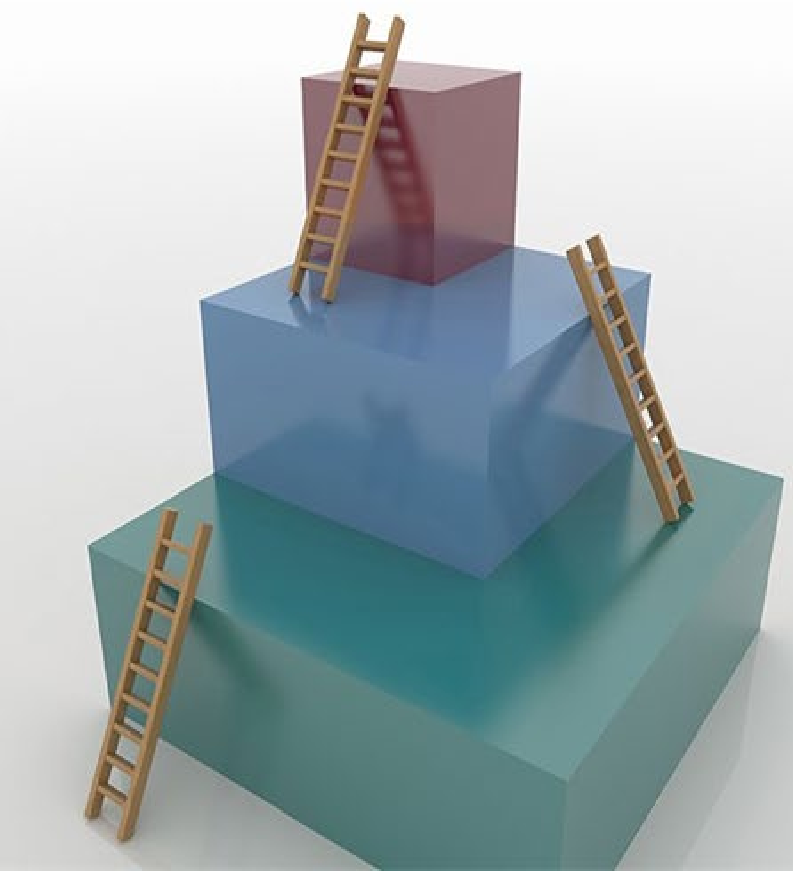
Process

Guidance: Lead Author Team

- Executive summary Manoela Miranda, *UN Environment Programme*
- Atmospheric mercury monitoring Lynwill Martin, *South African Weather Service*
- Biota mercury monitoring David Evers, *Biodiversity Research Institute*
- Human biomonitoring Nil Basu, *McGill University*
- Cross-media data analysis Colin Thackray, *Harvard University*
- **Supplementary material:**
- Part A: monitoring programmes and SOPs
- Part B: QA&QC procedures and draft template

Setting the Stage –Chapter 2

Tiered approach:



- **Tier 3:** Basis for understanding key processes that link sources to environmental concentrations and exposures
- **Tier 2:** Basis for assessing source attribution at the local, national, and global scales. Methods may be more expensive or complex (Research)
- **Tier 1:** Limited set of parameters. Methods are cost effective, practical, feasible, and sustainable

Chapter 3: Why Atmospheric Mercury Monitoring

- Minamata Convention Article 1 = "protect human health & Environment"
- Reports by AdHoc Experts Group Highlights Air as a suitable matrix to help evaluate the Convention's effectiveness
- Mercury is a naturally occurring element and is emitted to the atmosphere from a variety of sources
- There are three forms or species/fractions of mercury commonly found and measured in the atmosphere:
    - Gaseous elemental mercury (GEM)
    - **Gaseous oxidized mercury (GOM)**
    - Particle-bound mercury (PBM)

REACTIVE MERCURY (RM)

- GEM/TGM Measurements well established and good comparability achieved already
- Uncertainty associated with commercially available Speciation Unit for RM measurement satisfactory results obtained during comparison (AMNet & Can) but room for improvement

Steffen, A., Scherz, T., Olson, M., Gay, D., and Blanchard, P.: A comparison of data quality control protocols for atmospheric mercury speciation measurements, Environ. Monit., 14, 752– 765, 2012.

Why are we interested in measuring RM for EE

- Atmospheric RM is meaningful to reveal the behaviors of regional atmospheric mercury cycles and identify the contribution of local or regional emission sources
- RM measurements also provide valuable information e.g help evaluate models
- It’s important as they help to improve the understanding of short-term oxidation processes regarding the removal of mercury from the atmosphere
- Monitoring of RM for EE makes sense only if there is a universally agreed upon, reliable, and accurate method for it. (New studies/research)

Why Use a Tiered Approach?

With over 135 Parties that have ratified the MC, fewer than 20% of countries have an Air Monitoring Program that **is currently active**

Guidance looks at the following:

- Parties with no monitoring activities
- Parties that use one method of sampling (e.g., wet deposition in APMMN)
- Parties that have two or more techniques of Hg air monitoring
- Parties that have well established network of stations and can do advance research or Hg monitoring

Tiered approach is the best way to meet all Parties Needs that no Party is left behind in Making Mercury History

Why Use a Tiered Approach?

Monitoring category	Observation Data	Metadata	Ancillary Data	• Analyses
Air - Tier 1	TGM and GEM levels; Wet deposition The measurement methods **cost effective**, **practical**, feasible, and sustainable. Automated, **Manual, Passive, wet deposition** methods	Latitude; longitude; elevation; Sampling time, frequency, duration; averaging methods; sampling method	Measurement/method uncertainty; proximity to known point sources; type (urban/regional/background); meteorological variables;	• Temporal trends • Atmospheric model evaluation (for GEM) • Spatial variations • Input for local-scale modelling • Back-trajectory analysis • Bottom-up attribution analysis
Air - Tier 2	Air - Tier 1 and High-resolution PBM and GOM; Estimates of dry deposition of mercury (using concentrations and site specific deposition velocities); mercury throughfall	Air - Tier 1	Air - Tier 1 and deposition of Sulfate; Land Cover; Land Use; Leaf Area Index; Air Quality Tracers (e.g., SO_2, CO_2, CO, $PM_{2.5}$, O_3)	• Air - Tier 1 and • Estimate air-ocean and air-terrestrial mercury exchange • Covariate profiling • Top-down attribution analysis
Air - Tier 3	Air - Tier 2 and mercury isotopes; Measurements of dry deposition; additional speciation measurements Speciation Measurement with new techniques Prototype Equipment	Air - Tier 2	Air - Tier 2	• Air - Tier 2 and • Combined "top-down" and "bottom-up" attribution analyses • Isotopic fingerprinting

Source: UNEP/MC/COP.4/INF/12

Tier 2 & 3 Monitoring Provides Opportunity for RM…

- New research to investigate these findings that could help the Convention on monitoring to maintain harmonized, comparable information on mercury levels in the environment **Decision BS-3/10**
- Article 19 focus on **Research Development and Monitoring**
- Following talks will highlight this current/new research approach of improving our understanding of RM measurements

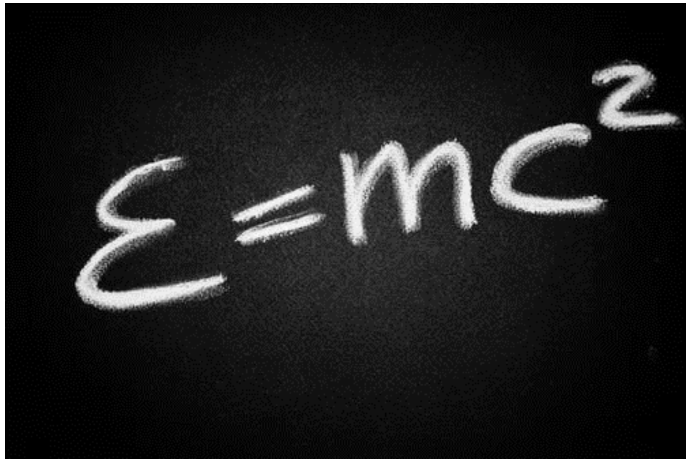
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

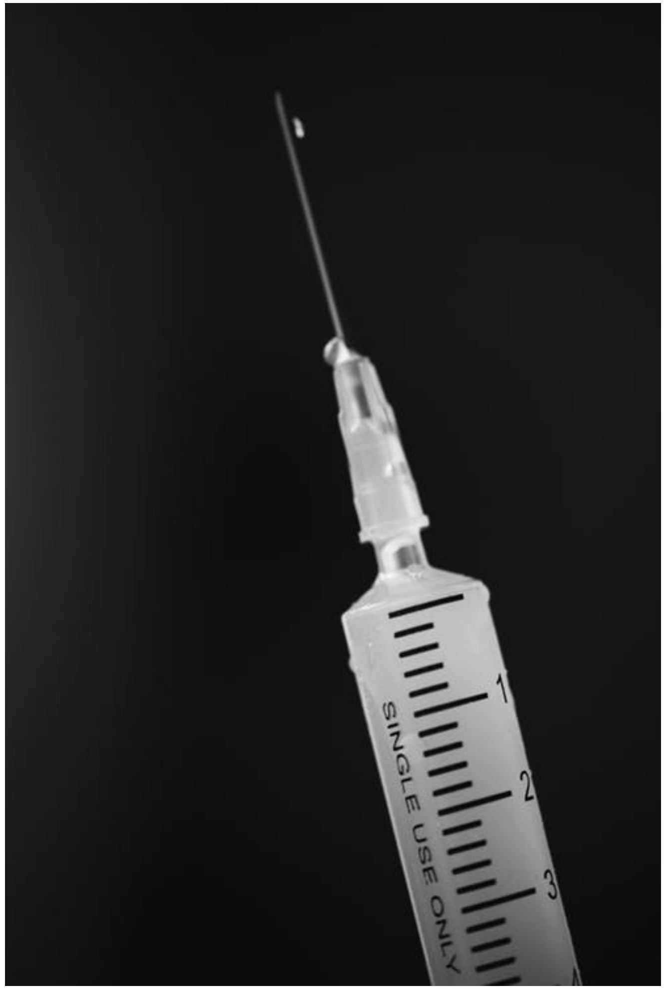
Comparability of the measurement results for gaseous elemental mercury (GEM)

Iris de Krom – National Metrology Institute – VSL

1 March 2022 – Minamata online

Importance of measurements





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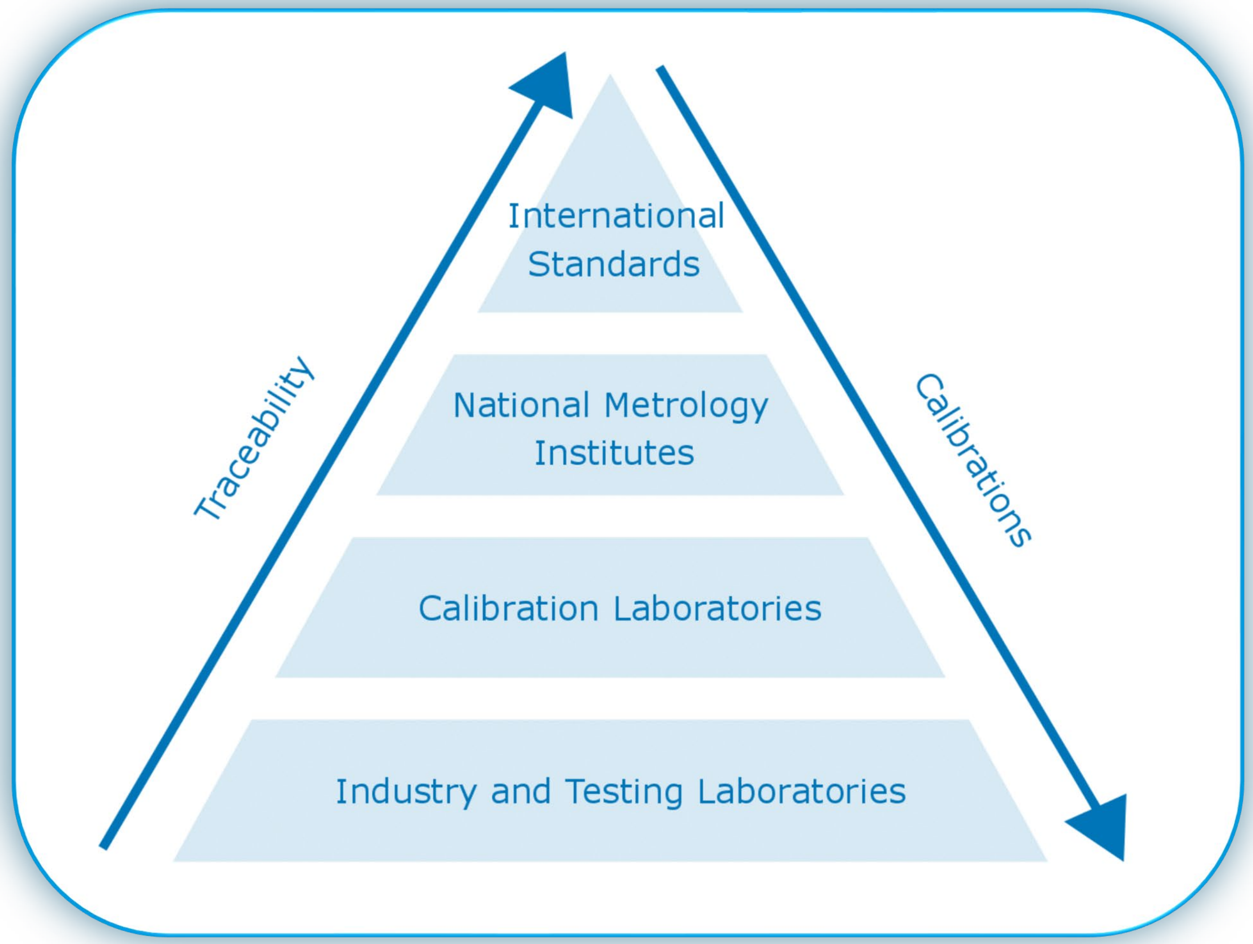
Metrological traceability

- Metrology is the science of measurement. Metrology includes all theoretical and practical aspects of measurement.
- Traceability is the ability to verify the history, location, or application of an item by means of documented recorded identification. (“Trackability”)
- The term "metrological traceability" is used to refer to an unbroken chain of comparisons relating an instrument's measurement results to a known measurement standard.

National Metrology Institute

SI-traceability



The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

VSL

National metrology institutes

- Aim
  - Knowledge of national metrological structure
- Subjects
  - Système International (SI)
  - Measurement standards
  - Developments
  - Key Comparisons

EMPIR EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Traceability of gaseous elemental mercury

- EMRP ENV02 PartEmission (2010 – 2013)
- EMRP ENV51 MeTra http://projects.lne.eu/metra/ (2013 – 2016)
  - Development of traceable calibration methods for mercury
- EMPIR 16ENV01 MercOx http://www.mercox.si/ (2017 – 2020)
  - Development of traceable calibration methods for oxidised mercury
- EMPIR 19NRM03 SI-Hg http://si-hg.eu/ (2020 – 2023)
  - Metrology for traceable protocols for elemental and oxidised mercury concentrations

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

VSL

Primary Mercury Gas Standards

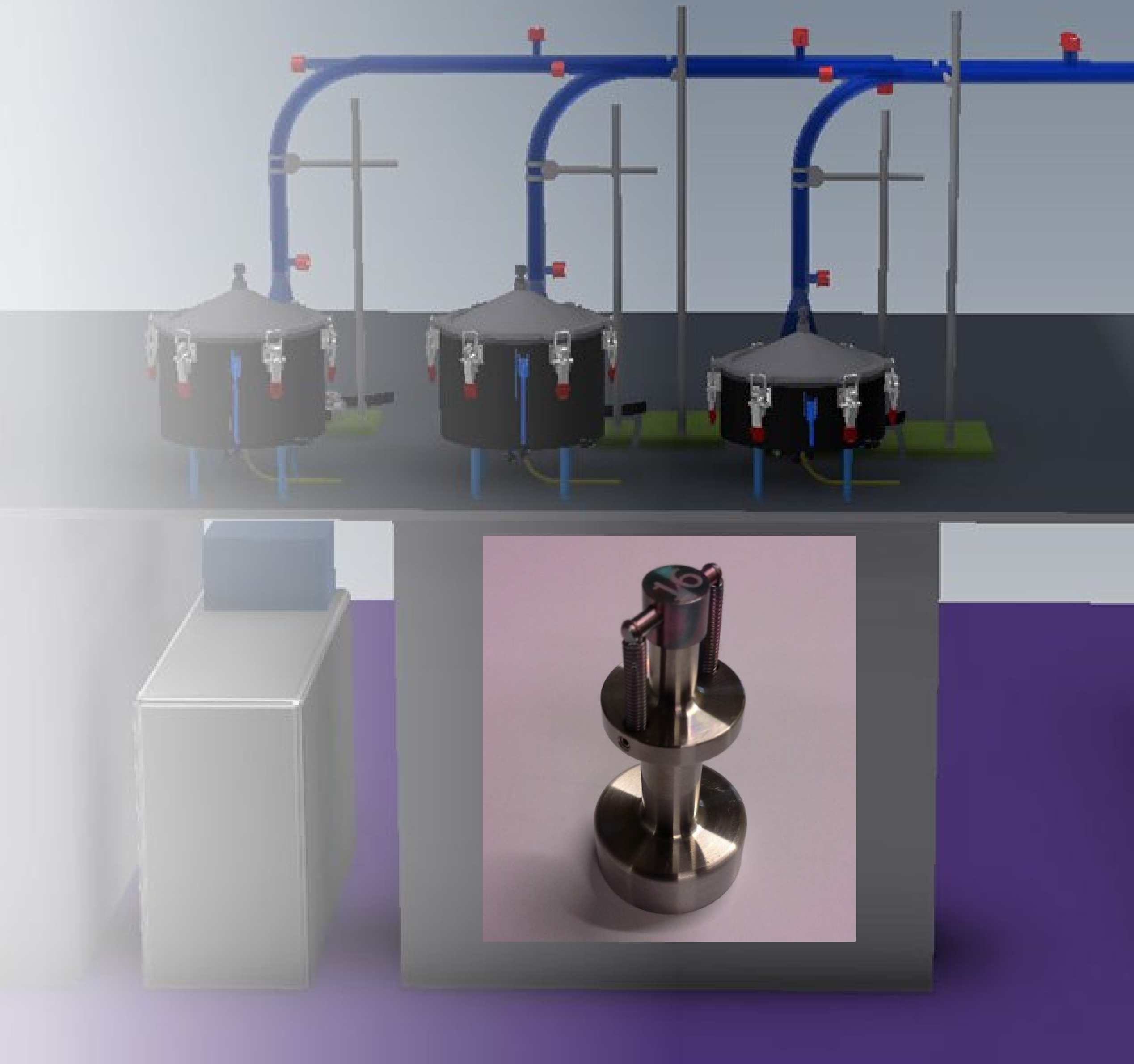
- Gaseous Elemental Mercury → GEM
- Traceable to SI-units
- Uncertainty

- VSL – diffusion method

de Krom et al. Measurement 169 (2021) 108351
doi: https://doi.org/10.1016/j.measurement.2020.108351
de Krom et al. Atmos. Meas. Tech., 14 (2021) 2317
doi: https://doi.org/10.5194/amt-14-2317-2021

- NIST – spectroscopy

Srivastava et al. Anal. Chem. 90 (2018) 6781
Doi: https://doi.org/10.1021/acs.analchem.8b00757
Srivastava et al. Anal. Chem. 93 (2020) 1050
Doi: https://doi.org/10.1021/acs.analchem.0c04002



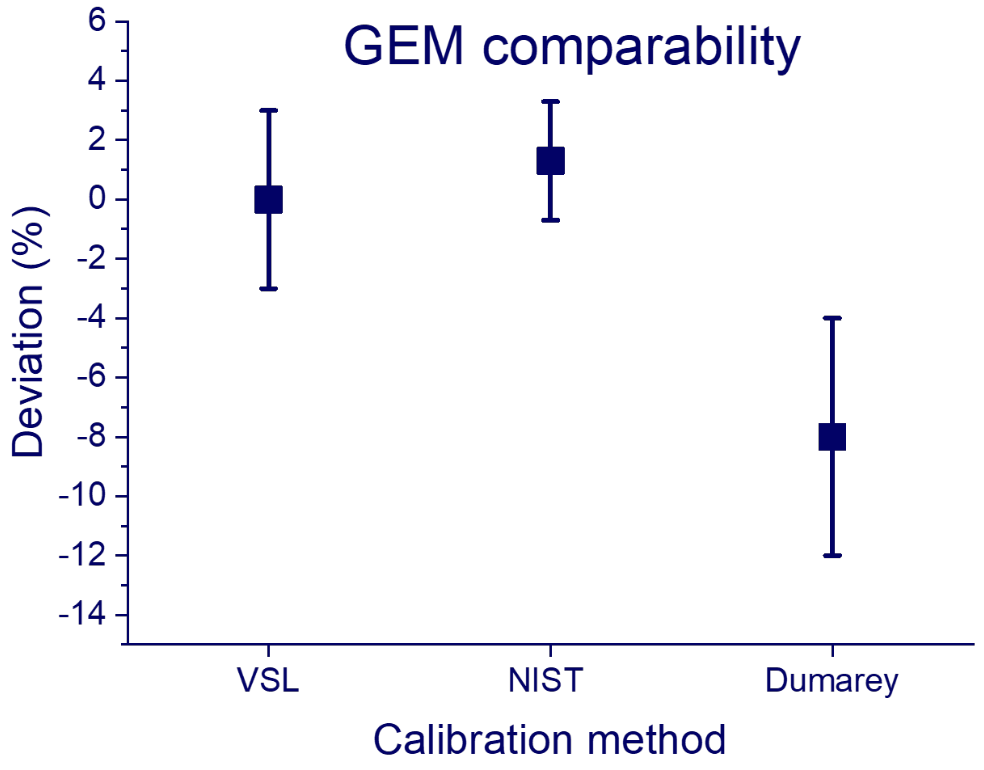
Comparability of the measurement results for gaseous elemental mercury (GEM)

SI traceable reference materials

VSL gas generator & NIST SRM (3133)

Field method

Dumarey equation



The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Traceability for elemental mercury measurement results

- Traceability for gaseous elemental mercury (GEM)
  - In emission sources and the atmosphere
  - Comparisons between current calibration facilities
    - Dumarey equation
    - NIST SRM
  - Calibration services

- Future
  - SI traceability in written standards
  - Unbroken chain of mercury measurement results from primary standards to industry and monitoring programmes


Contact Info:
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idekrom@VSL.nl
www.SI-Hg.eu

Practical demonstration of oxidized mercury measurements: sampling artifacts and calibration

Mae Sexauer Gustin[1,*], Seth Lyman[2], Sarrah M. Dunham-Cheatham[1], Milena Horvat[3]

[1] University of Nevada, Reno, Reno, Nevada, USA
[2] Bingham Research Center, Utah State University, Vernal, Utah, USA
[*] mgustin@unr.edu

[3]Jožef Stefan Institute, Ljubljana, Slovenia

Scientific Process

Scientific understanding evolves over time

Progress is made as

- Our knowledge increases
- Our methods improve

Jožef Stefan Institute

Oxidized Hg

Why is it important to measure?

- Emitted from point sources at high concentrations
- Also present in the air we breathe, or “ambient air”
  - Derived from:
    - Point sources
    - Chemical reactions in the atmosphere with Hg^0
    - Emissions from natural sources

Here, we will focus on **ambient atmospheric** measurements, not emission measurements

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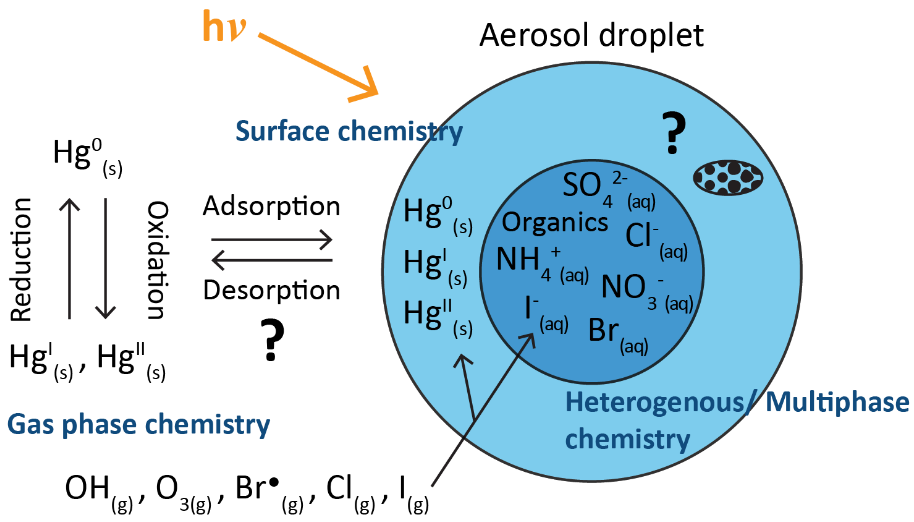
Oxidized Hg Measurement Challenges

Difficult to measure

- "Sticky"
- Reactive
  - Can be reduced to elemental Hg^0 depending on atmospheric chemistry
- Low concentrations (low parts-per-quadrillion)



Methods to measure have evolved over time

- First used manual denuders for GOM and filters for PBM

Tekran, in collaboration with others, developed an automated system for operationally defined GOM and PBM measurements

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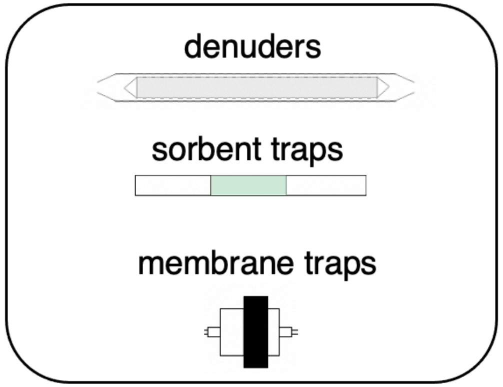
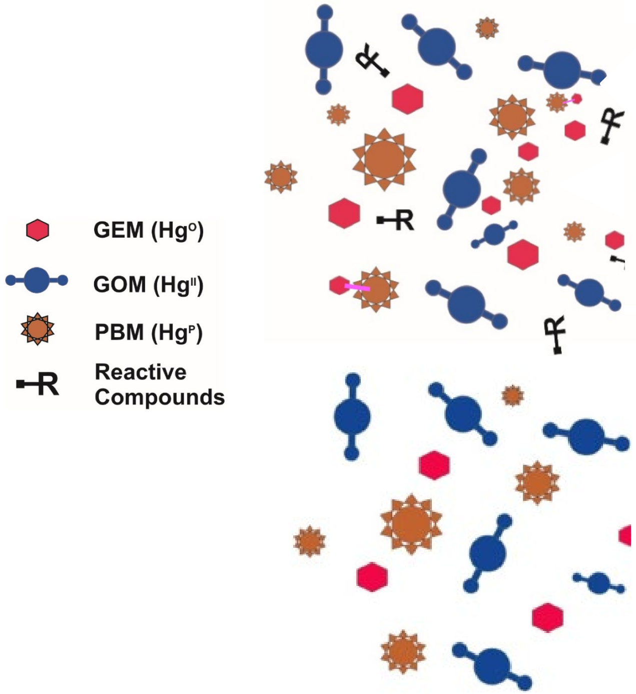
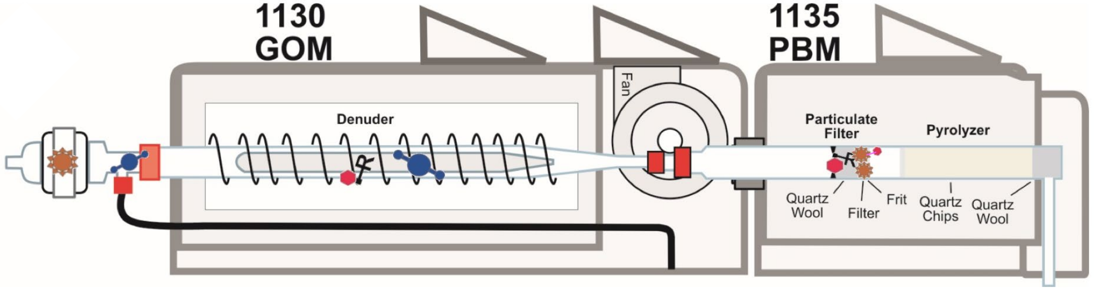
Common Methods

Preconcentration methodologies:

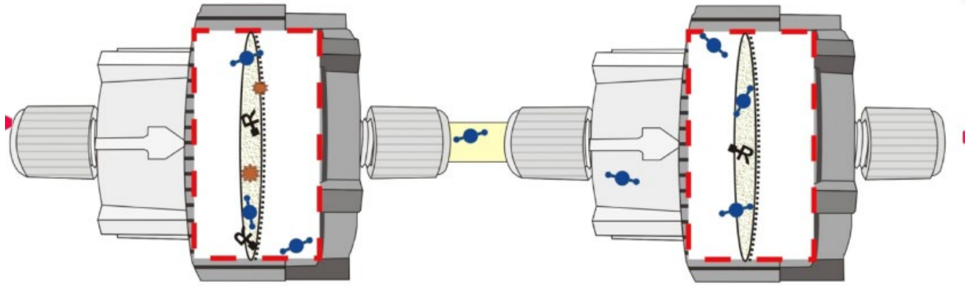
- GEM (Hg^0): gold traps, AC traps, oxidizing solutions
- GOM (Hg^{2+}): KCl denuders/sorbent traps/impingers, ion exchange membranes







Denuders



Ion Exchange Membranes

Flow direction

Figures are the courtesy of E. Prestbo, Tekran

Jožef Stefan Institute

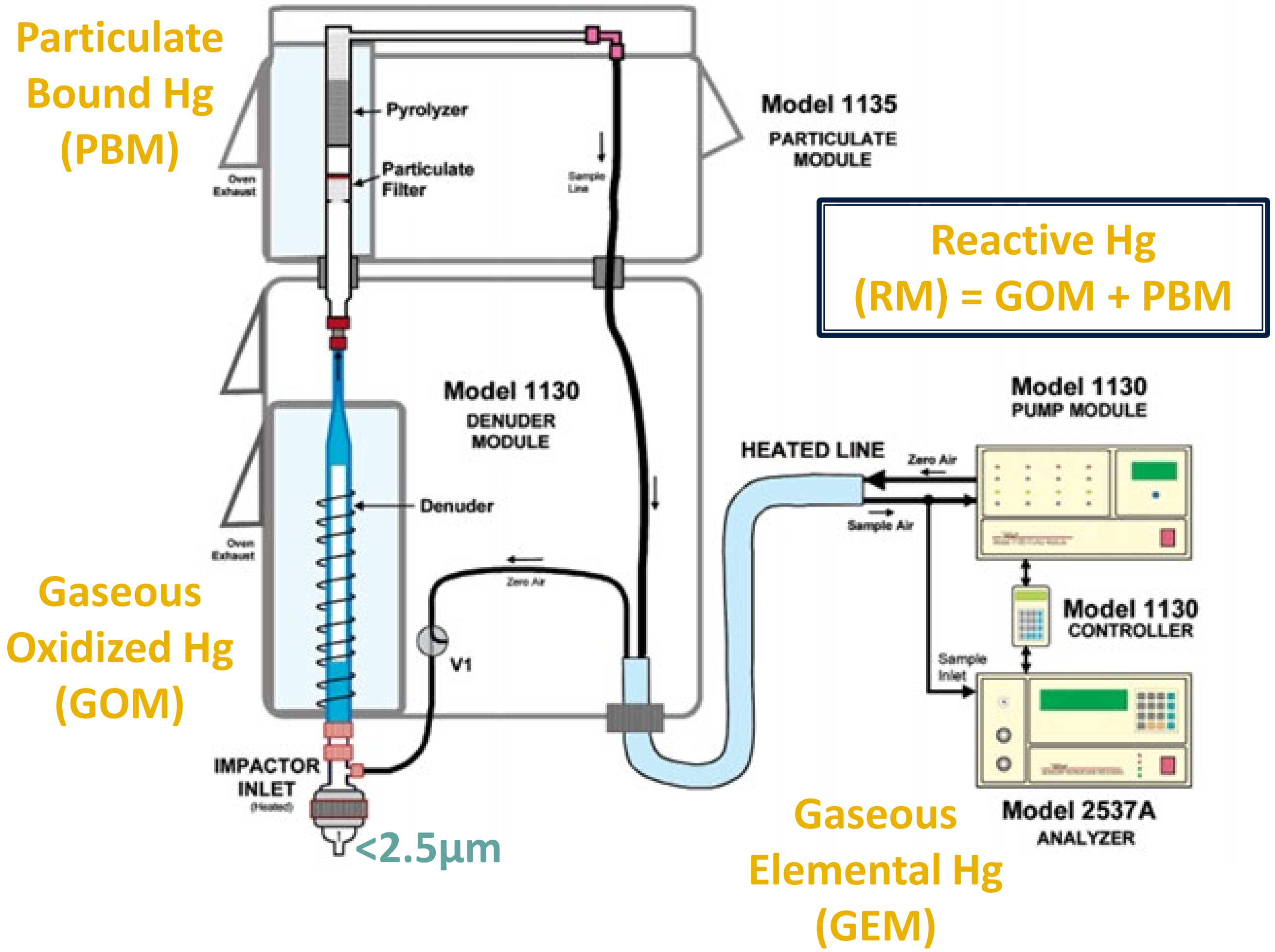
Tekran® System

Being used in networks world-wide

High uncertainty associated with GOM and PBM measurements

- GOM measurement is biased low by 2- to 13-times

No ambient air field calibration for GOM nor PBM



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Need for New Methods & Calibration

Over the past 10 years, it has become clear the Tekran GOM and PBM measurements are impacted by the chemistry of the atmosphere

- New accurate methods for GOM and PBM measurement need to be developed

Calibration **traceable** to an international standard is needed

- Achieving oxidized Hg calibration is not a minor task
  - Global community has been working on this for a decade
- Need of in **SI traceable** and/or **globally** agreed calibration method

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How to assure global comparability for GOM ?

Sampling	+	Processing	+	Measurement	=	Result
Representative Appropriate Contamination free Stability Handling		selective trapping of GOM		Comparison to SI units or conventional scale		± uncertainty

VIM definitions:

Traceability id the property of the **result of a measurement** or the value of a standard whereby it can be related to **stated references**, usually national or international standards, through an unbroken chain of comparisons all having **stated uncertainties**."

New Measurement Methods

Reactive Mercury Active System (RMAS): membrane-based measurement system

- RM, GOM, and PBM
- Developed by Gustin team

Dual Channel Systems: automated system

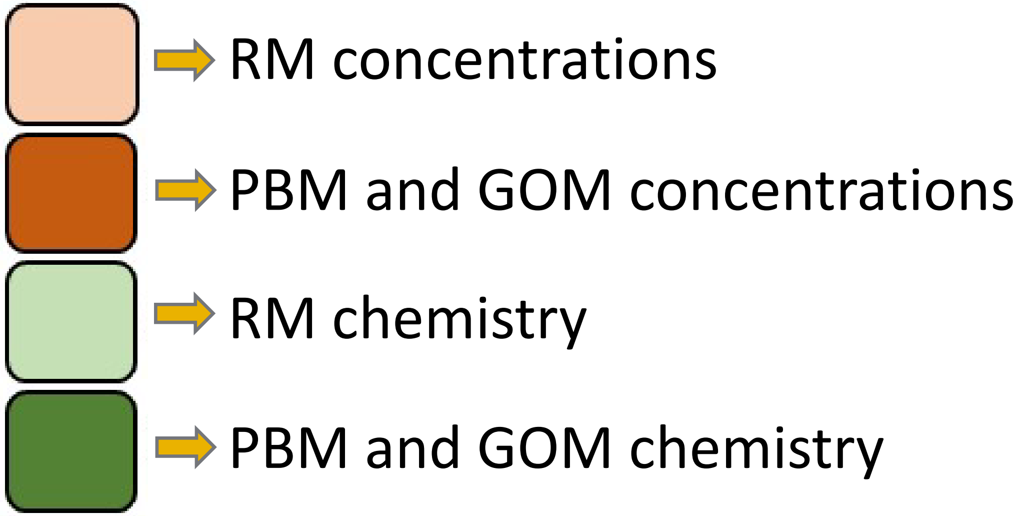
- RM, GOM
- Developed by Lyman and Gustin team
- MercOx dual channel system (Optoseven)
- NOAA and others are developing other dual channel systems

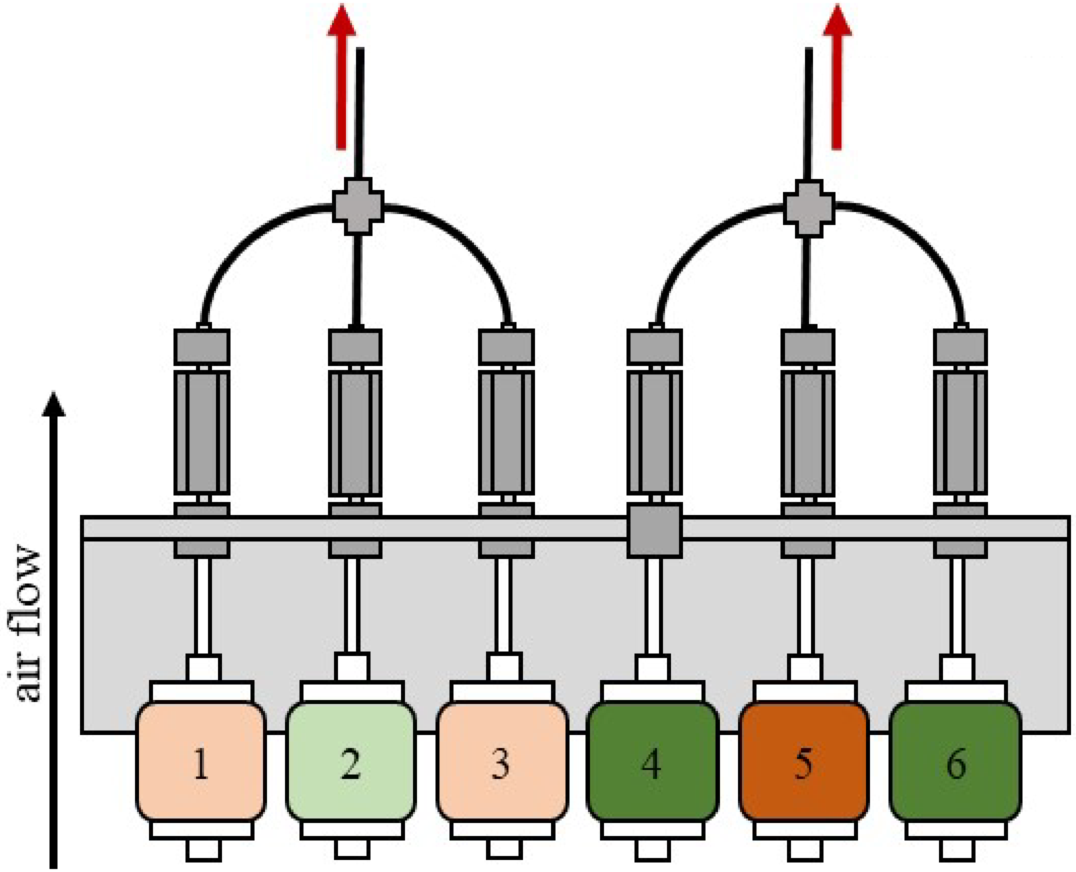
Reactive Mercury Active System (RMAS)

Ion exchange membranes capture RM, GOM, or PBM

Low-cost, easy to use, rugged

1- to 2-week resolution





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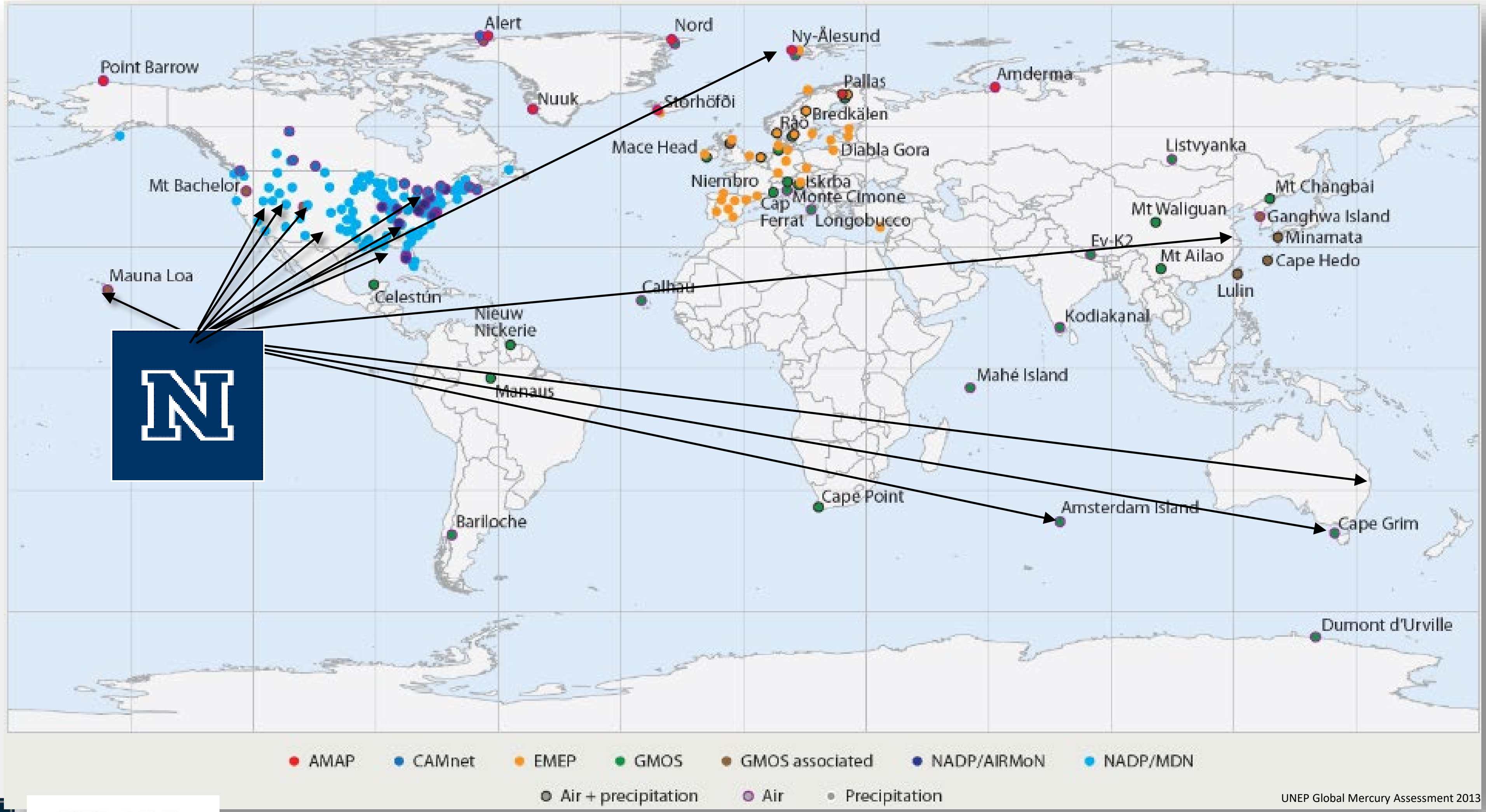
RMAS Deployment Locations



UNEP Global Mercury Assessment 2013

RMAS Membrane Analyses

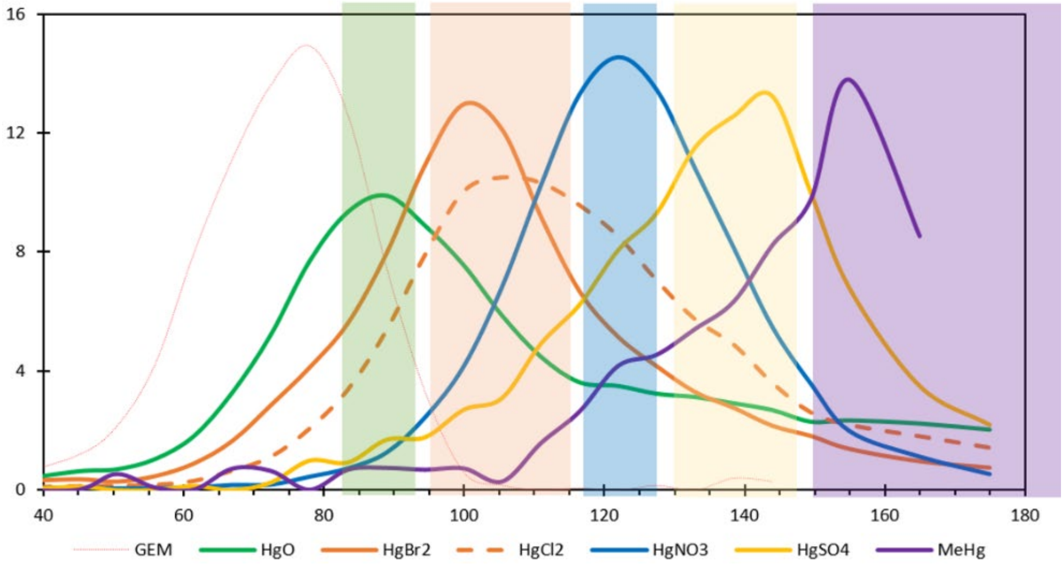
Total Hg Concentrations

- Digestion following EPA Method 1631
- Analysis by cold vapor atomic fluorescence spectroscopy

Tekran 2600-IVS (CVAFS)

Hg Chemistry

- Thermal desorption
- Individual Hg compounds desorb at characteristic temperatures



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Dual Channel Systems (DCS)

Automated systems, with high temporal resolution for RM and GOM measurements

Uses a front end inlet to sample ambient air, that is split into two air streams within the system

- Quantify atmospheric Hg (total concentration or fractions) using Tekran 2537 or Lumex

Dual channel systems are being developed by several teams

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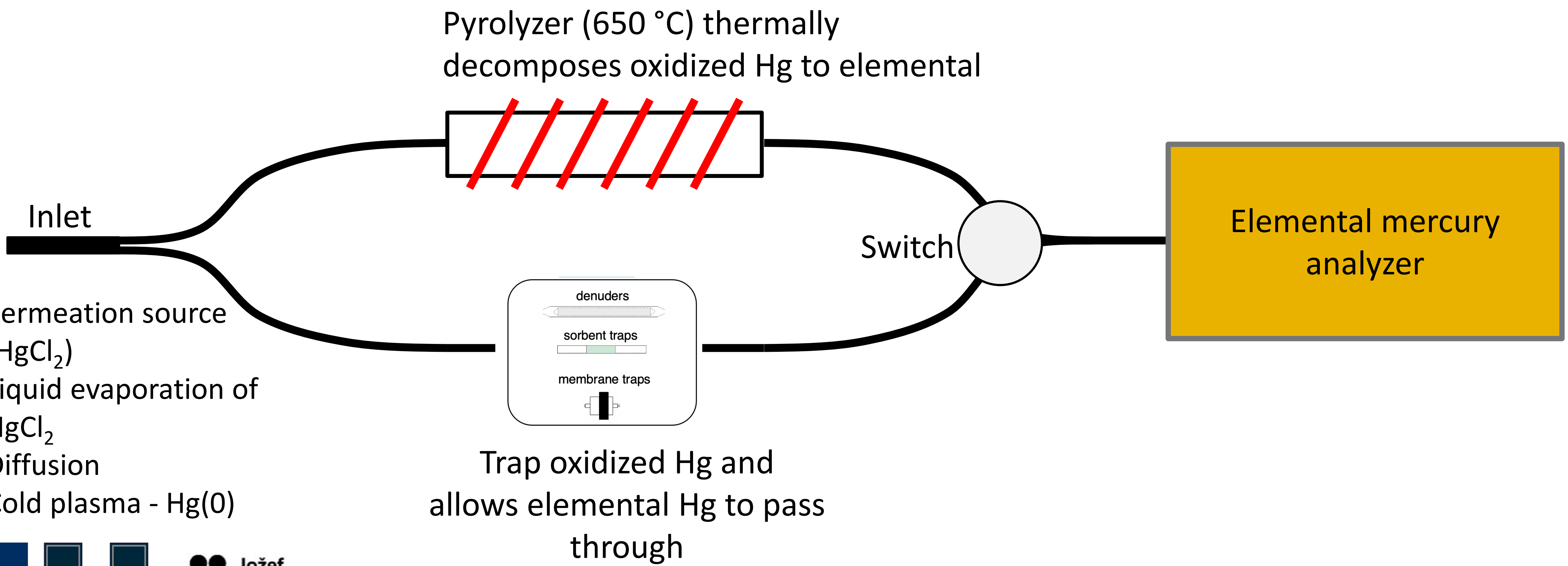
DCS Oxidized Hg Measurement

Dual channel systems use membrane technology to rapidly measure oxidized Hg



- Permeation source ($HgCl_2$)
- Liquid evaporation of $HgCl_2$
- Diffusion
- Cold plasma - Hg(0)

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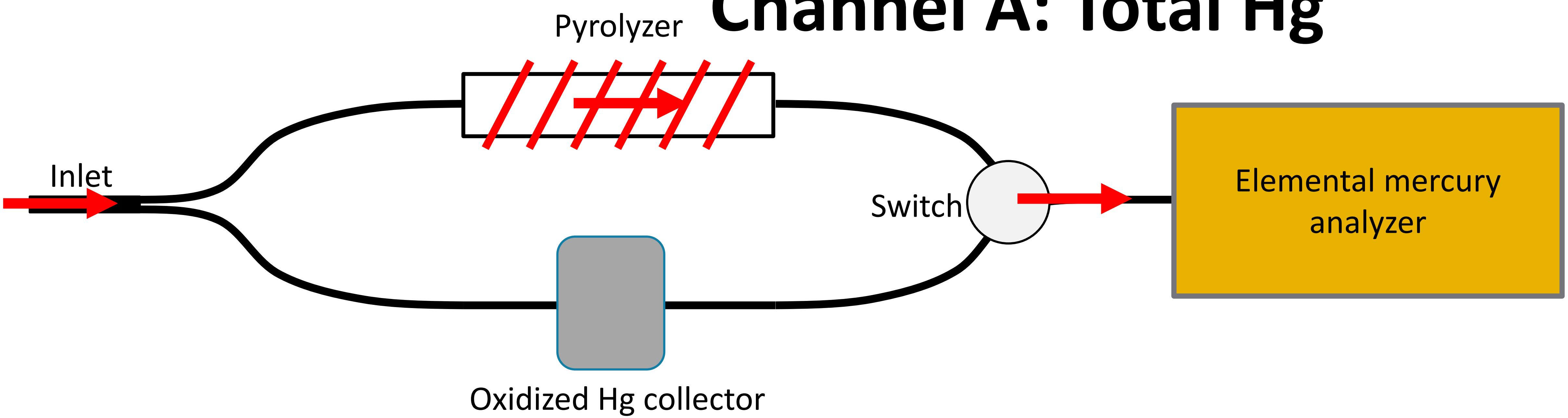
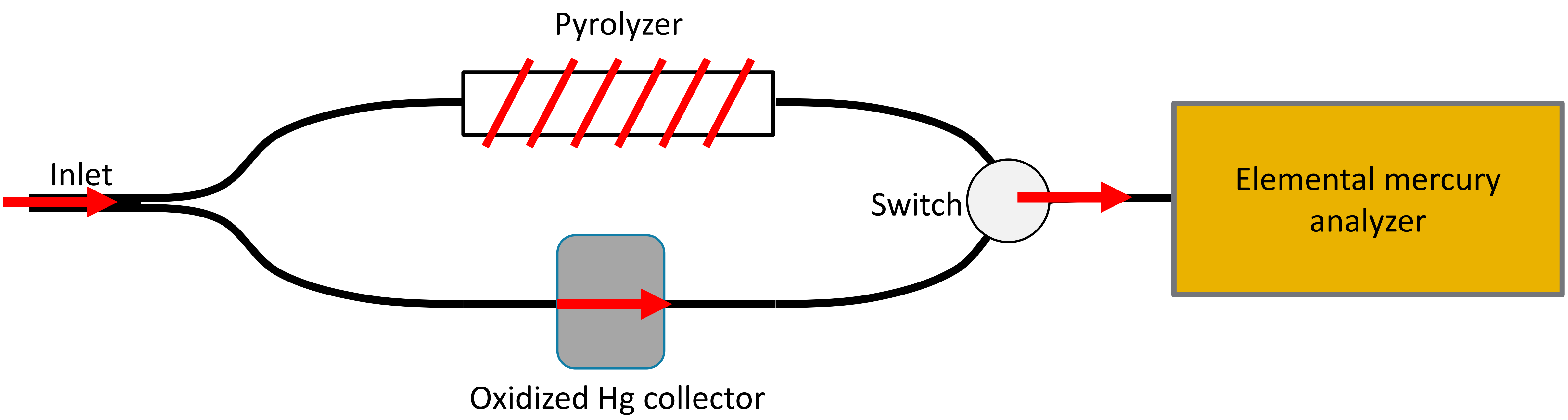
DCS Oxidized Hg Measurement

Channel A: Total Hg



DCS Oxidized Hg Measurement



Channel B: elemental Hg

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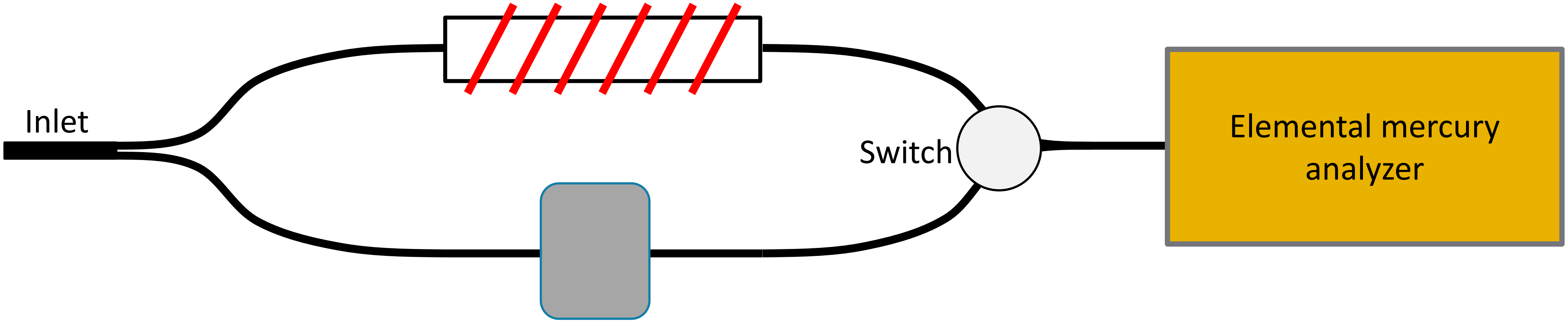
DCS Oxidized Hg Measurement

Total Hg (A) – elemental Hg (B) = Oxidized Hg



Calibration Requirements

Developed calibrated methods MUST be

- Traceable to **SI or an agreed standard**
- Comparable (**measurement uncertainty**)
- Stable source of oxidized Hg over time
- Field-deployable
- Economical
- User-friendly

Inter-comparison of calibrators is/will be needed

Oxidized Hg Calibration Methods

Need a standard method for calibrating methods used to measure reactive Hg

- Permeation tubes
- Diffusion
- Liquid standards
- Plasma

Development of a calibration system that may be used when making ambient air measurements in the field

- Several teams and institutions working toward this goal

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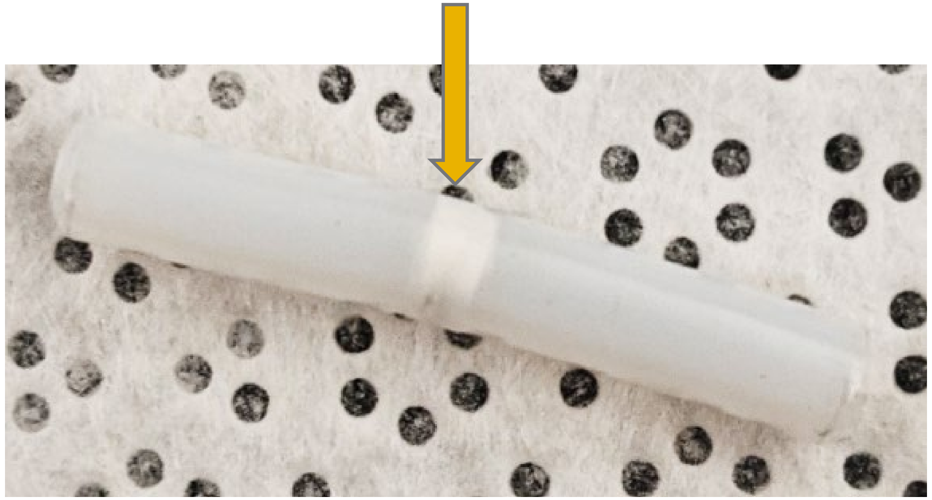
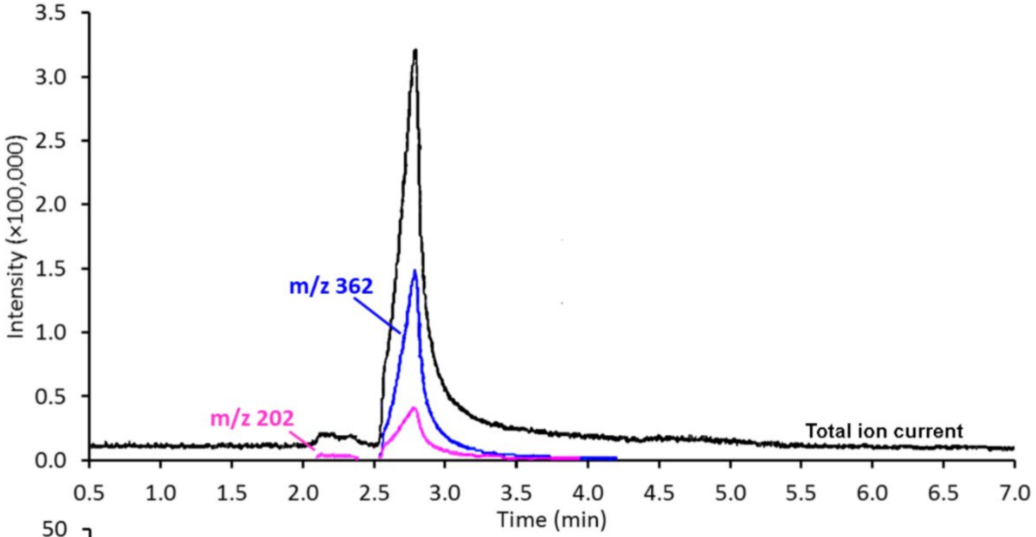
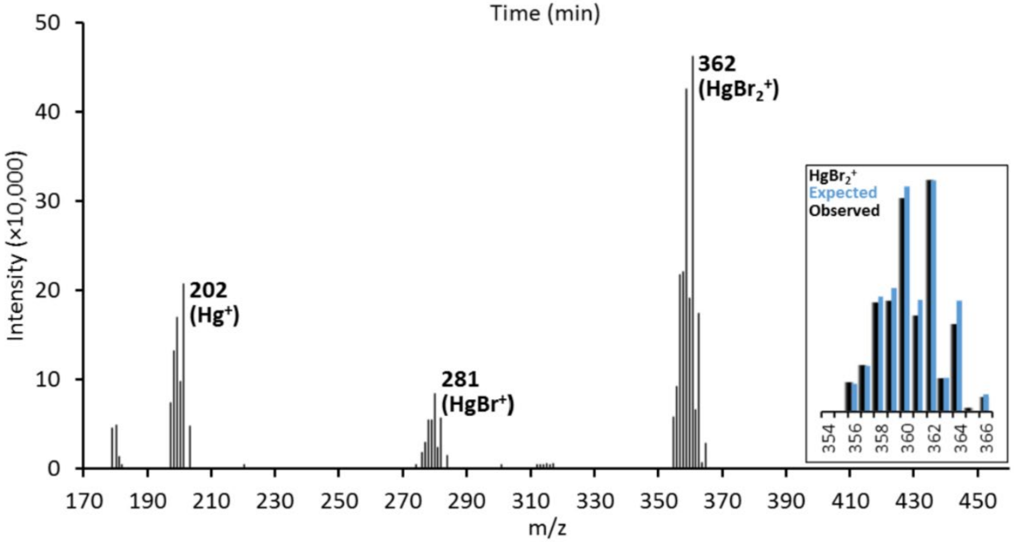
Permeation Tubes

Permeation tubes can be used to calibrate oxidized Hg

Hg solid, emits oxidized Hg vapor through tube wall

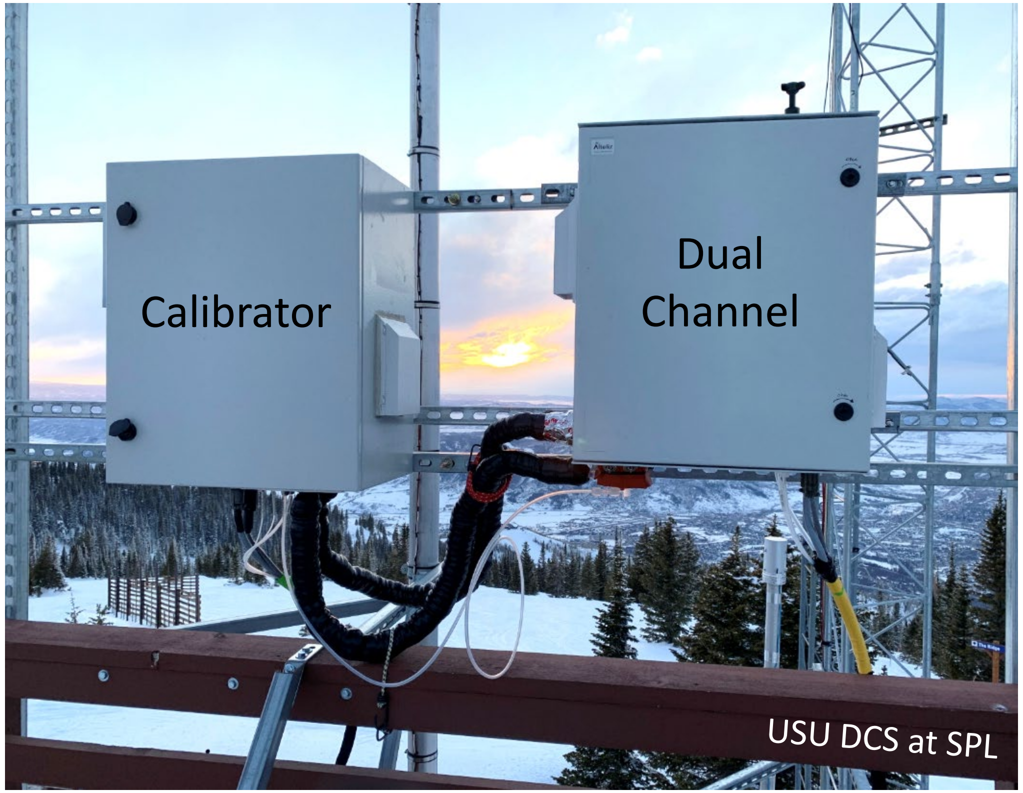


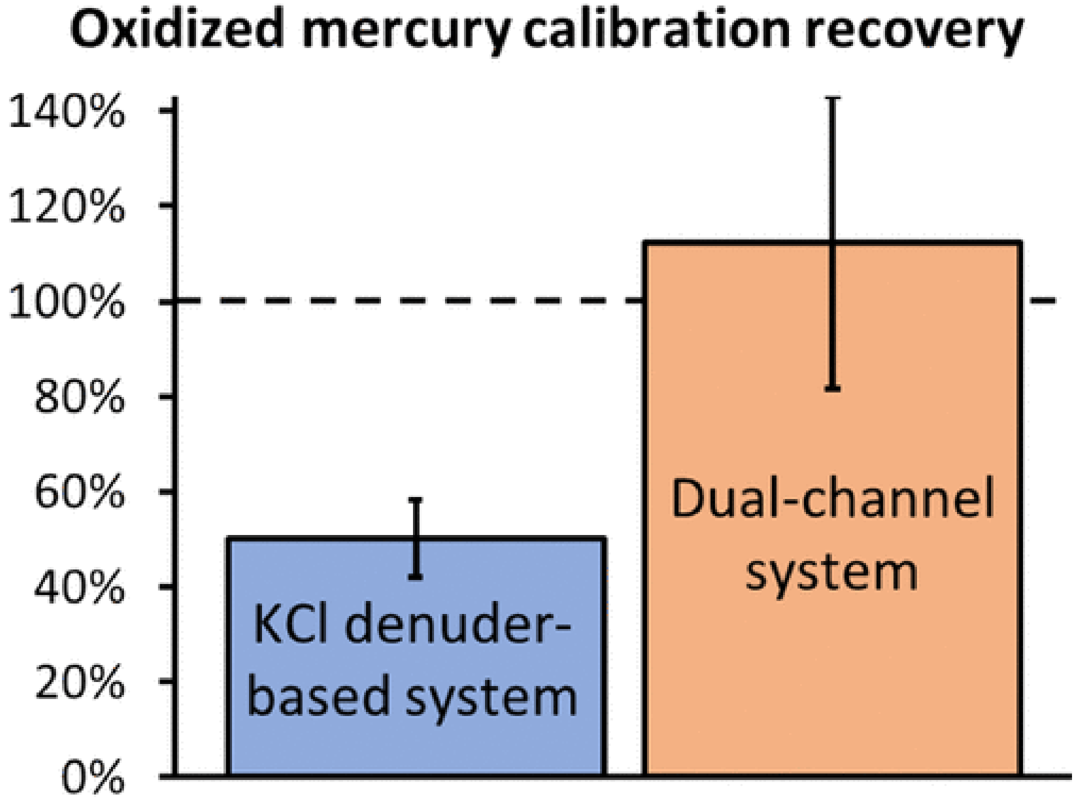




Permeation Tube-Based Calibrator

Dual channel systems can quantitatively recover oxidized Hg compounds from our calibrator





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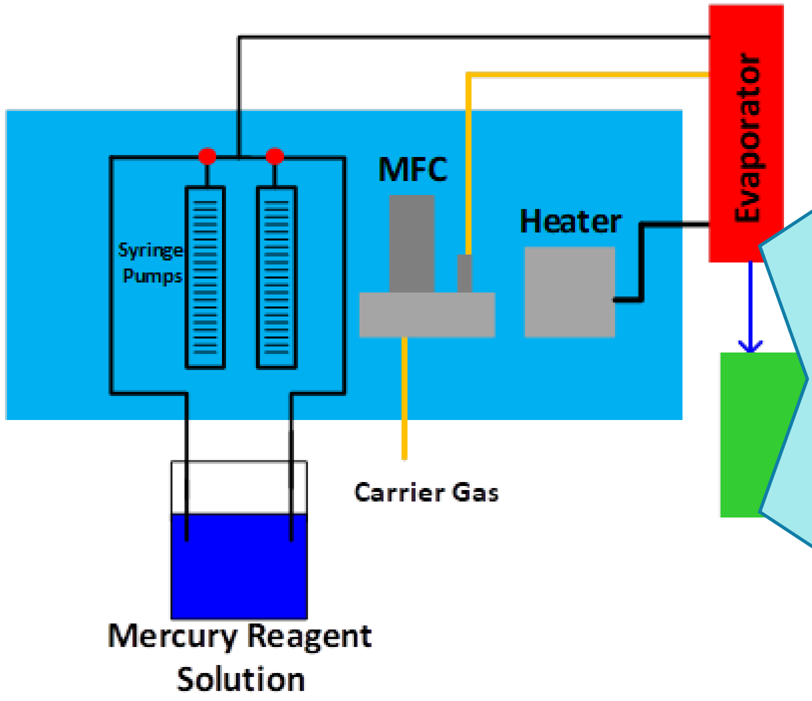
Evaporative GOM calibrator – MercOx/Optoseven

Liquid evaporative gas generator developed by Optoseven/Mercx project

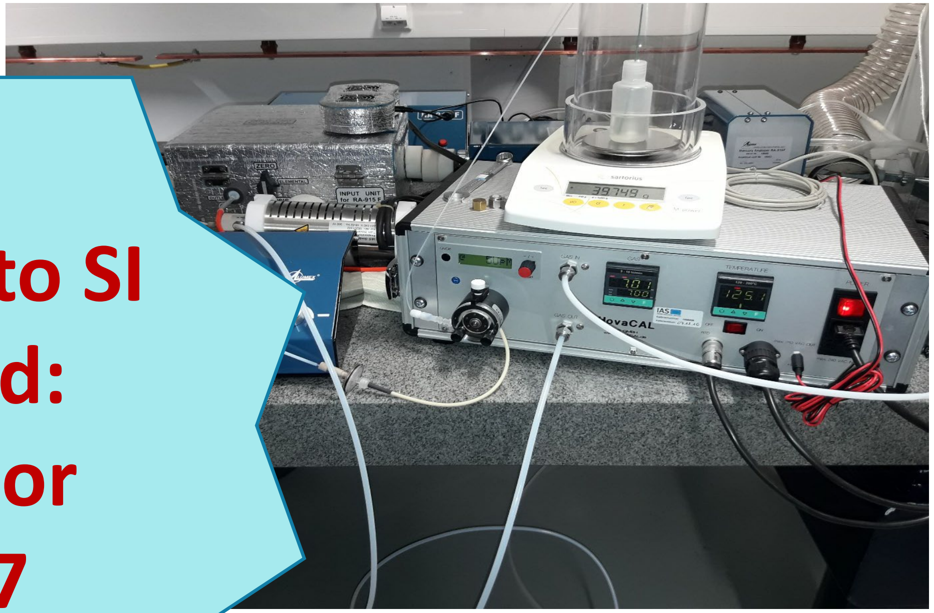
OPEN ACCESS
IOP Publishing
Measurement Science and Technology
Meas. Sci. Technol. 31 (2020) 034001 (14pp)
https://doi.org/10.1088/1361-6501/ab4d68

Dynamic calibration method for reactive gases

Saxholm Sari, Rajamäki Timo, Hämäläinen Jussi and Hildén Panu
VTT, National Metrology Institute VTT MIKES, Tekniikantie 1, FI-02150 Espoo, Finland



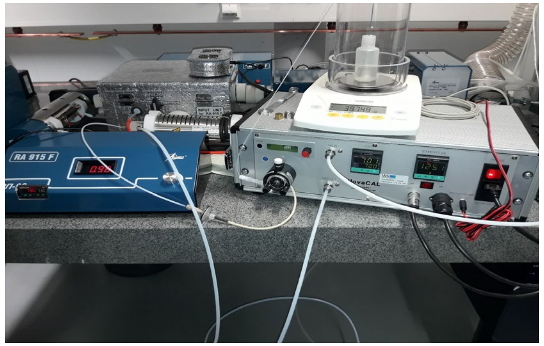
Traceability to SI established: NIST 3133 or NIST 3177

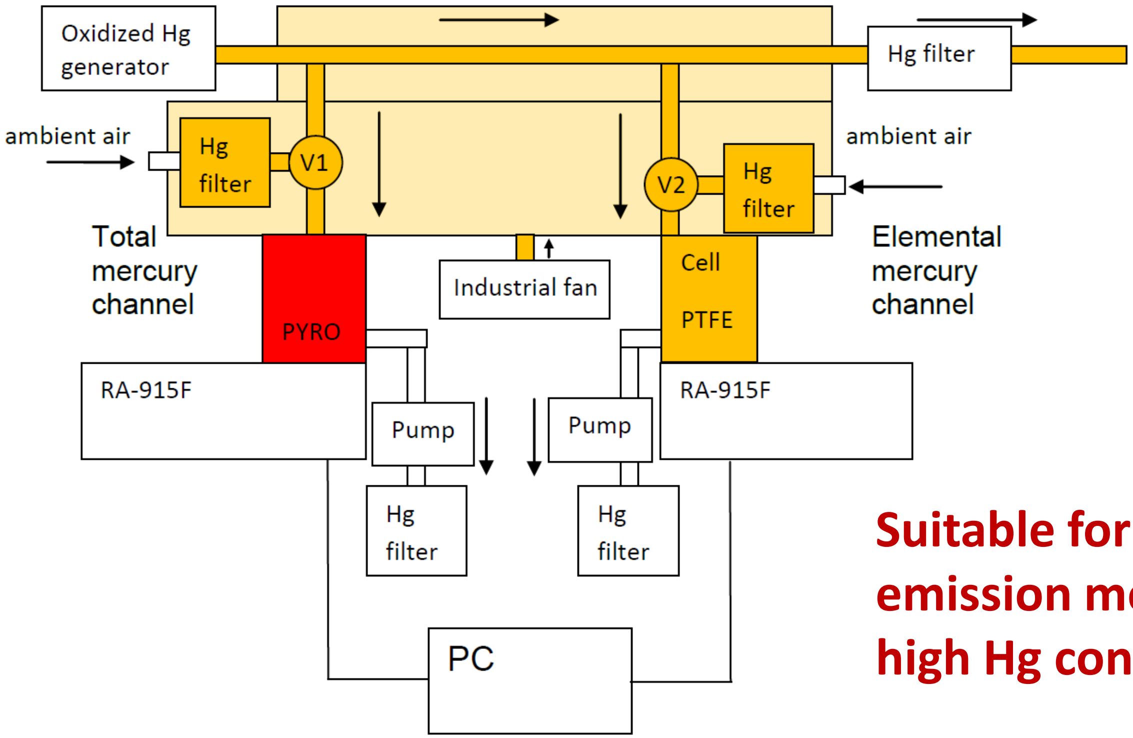


Calibration for GOM measurements

GOM generators: impurities of Hg^0 **(up to 5 %)**

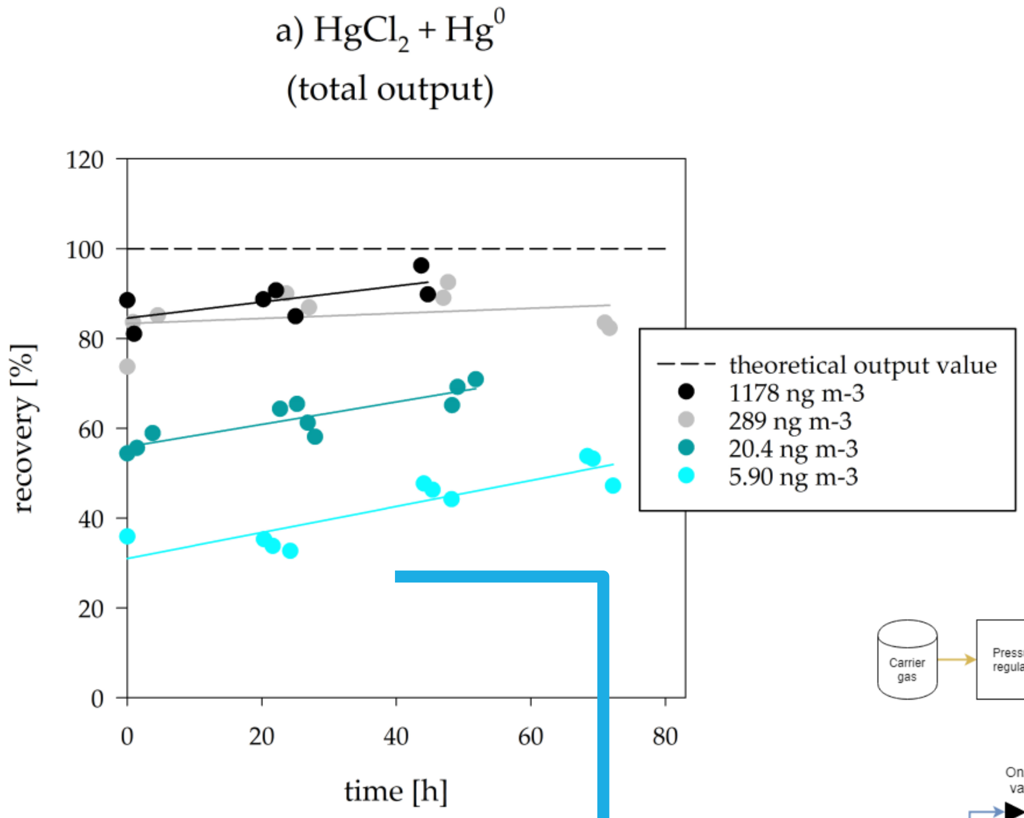
Lumex: MercOx two channel analytical set-up

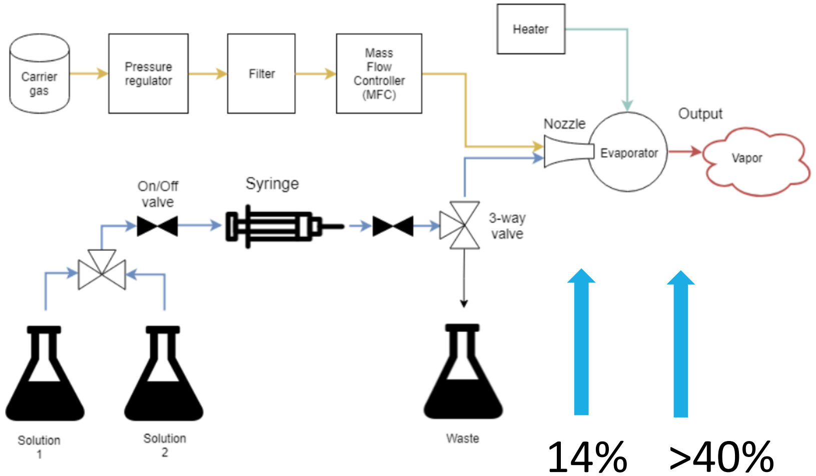




Suitable for on-line emission monitoring – high Hg concetrations!

MerOx/Optoseven calibrator output time-trends through different concentration ranges





14% >40%

sensors MDPI

Article

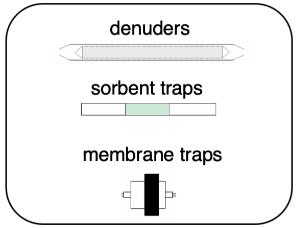
Validating an Evaporative Calibrator for Gaseous Oxidized Mercury

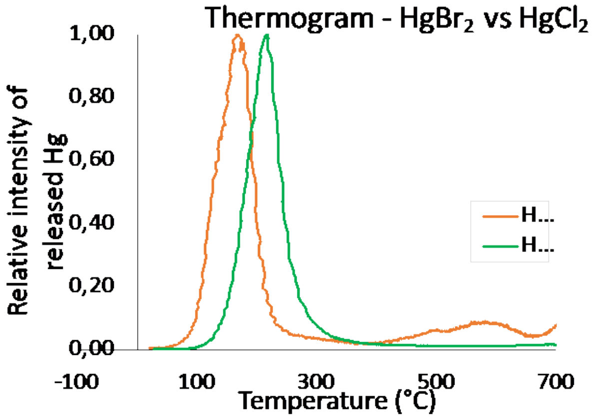
Jan Gačnik [1,2], Igor Živković [2], Sergio Ribeiro Guevara [3], Radojko Jaćimović [2], Jože Kotnik [2] and Milena Horvat [1,2,*]

Cold plasma GOM generation – traceability to NIST 3133 and 3177

Non-thermal or cold plasma

Atmospheric pressure and ambient T





Traceable quantity of Hg(0) in He gas

+air, Cl_2, Br_2

Quantitative conversion

Hg(0) → Hg(II) (HgCl, HgBr, HgO)

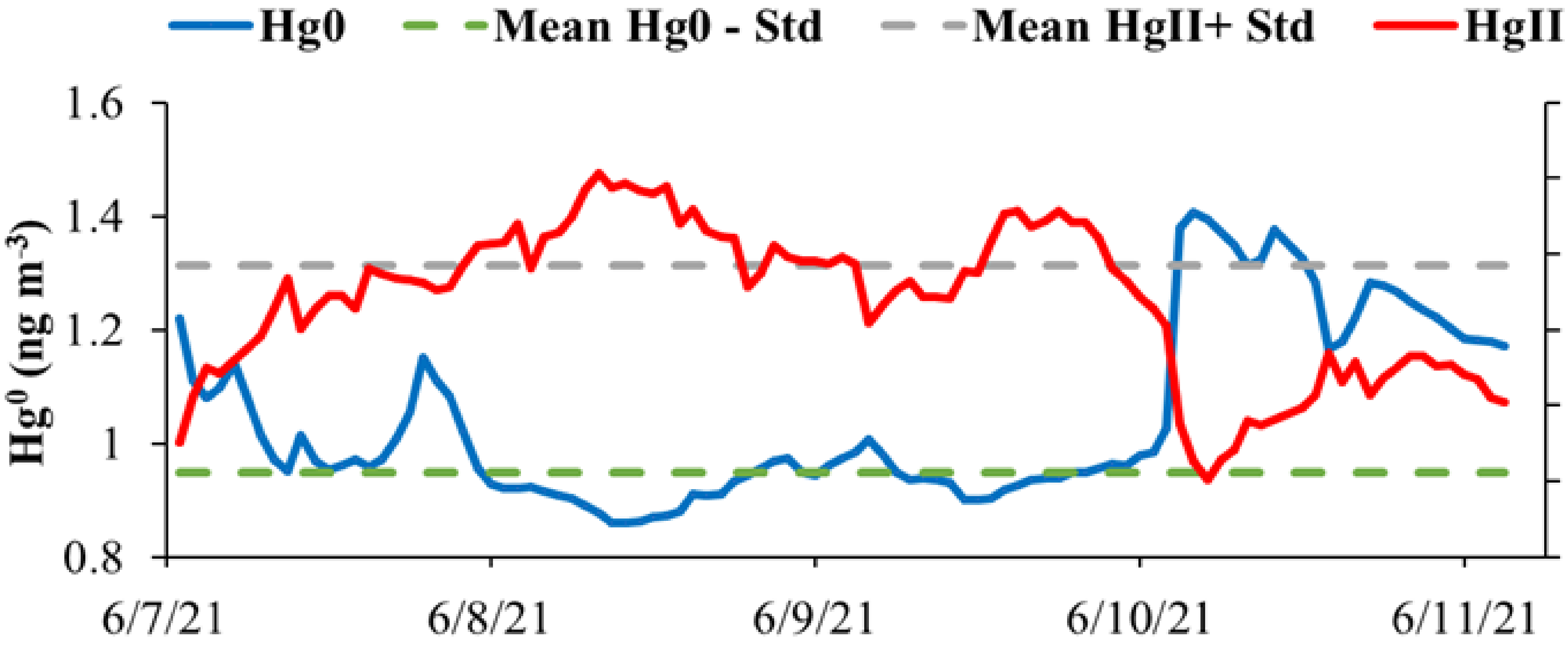
and 100% trapping efficiency

No detectable breakthrough of any Hg species

Gačnik et al., Anal Chem. 2022, Under review

USU DCS at Storm Peak Laboratory, CO

Detecting Hg oxidation events in air from the free troposphere



Tyler Elgiar working inside an automated calibrator

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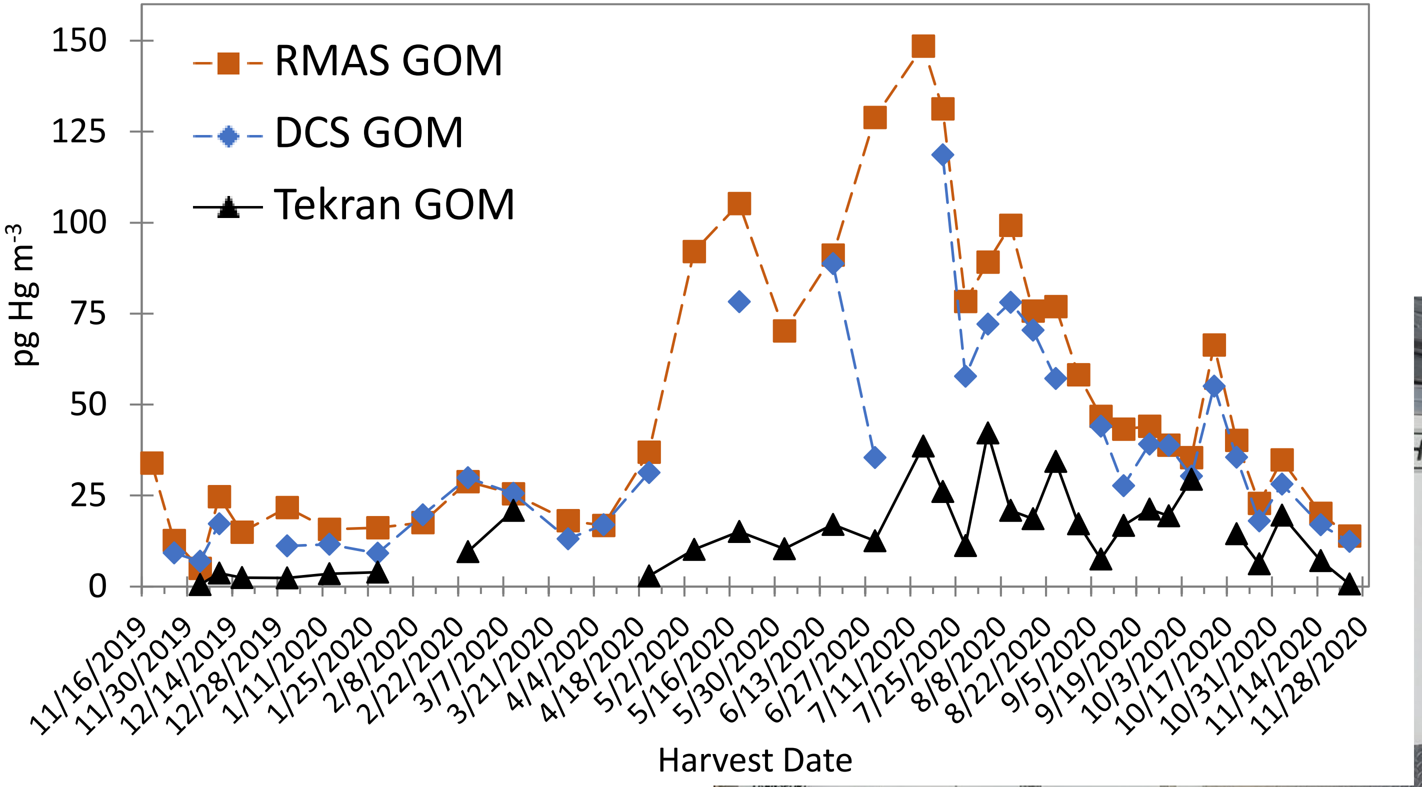
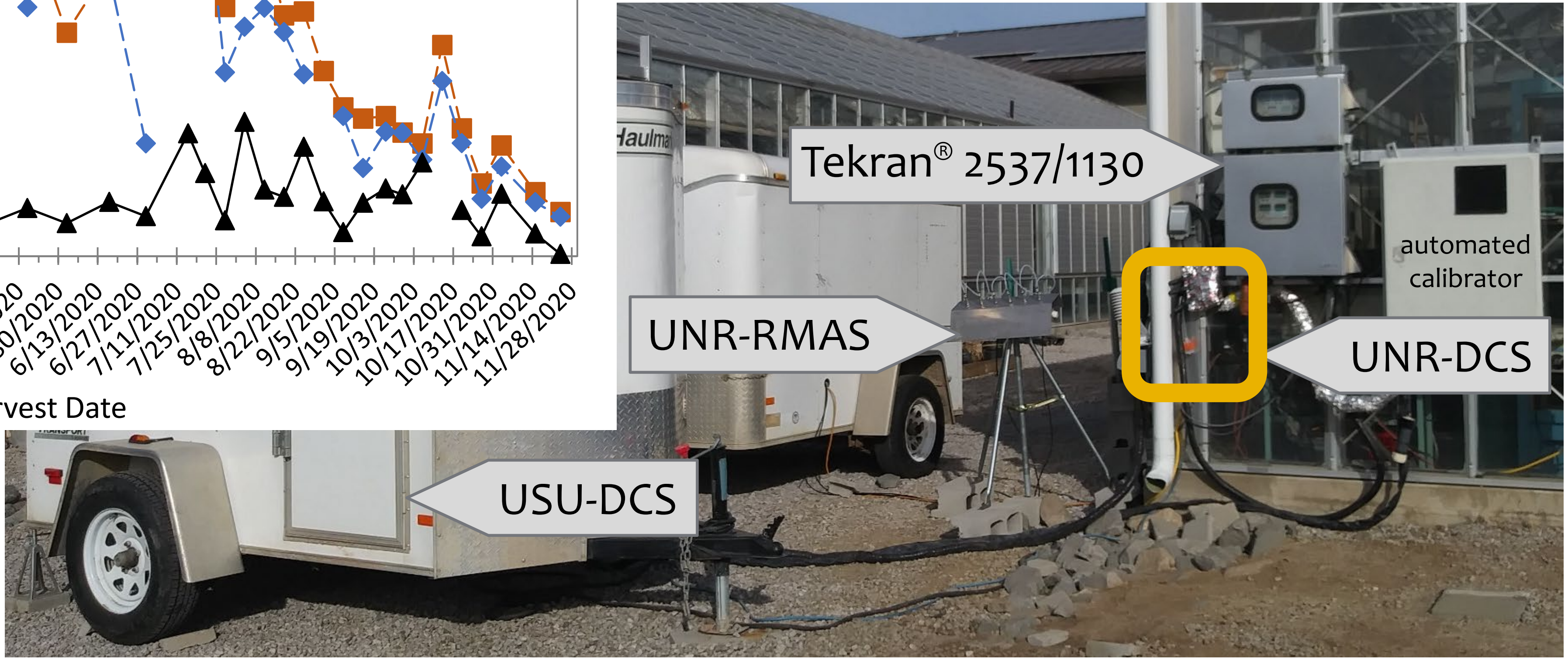
Comparison of Multiple Systems





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Conclusions & Next Steps

Research teams are making progress toward development of oxidized Hg measurement and calibration methods

New measurement methods are demonstrating comparability

New calibrator method is demonstrating accurate measurements by the RMAS and dual channel systems

Next Steps

- Continued development and testing of accuracy, precision, robustness, and comparability of newly developed measurement and **traceable** calibration methods
- Traceability is a key to comparability!
- Harmonization of new methods and demonstration of comparability is urgently needed by global community (i.*e., field inter-laboratory comparisons*)

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Thanks to the undergraduate and graduate students working in the Gustin and Lyman labs that help keep our research moving forward.

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MINAMATA CONVENTION ON MERCURY

Thank you for your attention

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